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UDC 539.377:678.067

Multipurpose Optimization of Elastic and Heat-Physical Properties of Fiber Composites

907D0122A Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 1, Jan-Feb 90 pp 37-47

[Article by A. F. Kregers, Yu. G. Melbardis, and M. F. Rektinsh, Institute of Polymer Mechanics, Latvian Academy of Sciences, Riga]

[Abstract] The purpose of this work is to demonstrate the possibility of multipurpose optimization of the planning of a fiber composite with predetermined properties. The optimization process is subdivided into stages: general statement of problem; selection of properties of composite material and variable parameters; determination of search area; development of an information plan for experiments; conduct of experiments (physical or in this case machine experiments); determination of mathematical models for each individual quality characteristic; multipurpose optimization based on the mathematical models found; verification experiments at the points of optimal solution. Where simple analytic expressions are available describing the properties of the composite material as functions of the controlled parameters, the work can be started immediately with the stage of multipurpose optimization, though such cases are rare. As an example, a carbon-carbon composite using two reinforcing systems, one flat the other solid, is analyzed. The characteristics studied are the elastic characteristics E, G, N, coefficients of linear thermal expansion and heat conductivity. Figures 5; References 17: 15 Russian, 2 Western.

UDC 629.7:678.067

Factors Influencing Compressive Strength of Layered Composites and Methods of Increasing It

907D0122B Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 1, Jan-Feb 90 pp 52-60

[Article by G. M. Gunyayev, I. G. Zhigun, V. A. Polyakov, and V. V. Mikhaylov, All-Union Institute of Aviation Materials, Moscow; Institute of Polymer Mechanics, Latvian Academy of Sciences, Riga]

[Abstract] The purpose of this work is to establish the basic factors influencing the predicted values of compressive strength of composites by analysis of experimental data utilizing an approach which is founded on hypotheses of the loss of stability of reinforcing fibers. The studies show that in order to achieve high values of compressive strength a binder must be used which has high values of shear modulus and a linear variation of tau with gamma, as well as reinforcing fibers which have high values of maximum deformation and compressive modulus of elasticity. The presence in a composite of even a small quantity of reinforcement, the strength of which is comparable to that of the binder, leads to a significant decrease in compressive strength as well as flexural strength. Figures 6; References 10 (Russian).

UDC 539.3

Nonlinear Deformation and Stability of Two-Layer Spherical Segments Exposed to External Pressure Considering Delamination

907D0122C Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 1, Jan-Feb 90 pp 80-84

[Article by V. A. Bazhenov and Yu. L. Dinkevich, Kiev Institute of Construction Engineering]

[Abstract] A method of numerical investigation of nonlinear deformation and stability of two-layer spherical segments exposed to external pressure is developed and implemented considering delamination in the axisymmetrical statement. The possibility is considered of the existence of zones of normal contact between the envelopes. The structures are considered to be in close contact in the contact area and free of shear forces. The interaction is formulated with respect to radial movement and surface contact forces at the nodes of a discrete model of the contact area. Numerical studies were performed using spherical segments rigidly clamped around their contours and exposed to axisymmetrical local loads. It is found that the elastic contact interaction has a significant influence on the maximum critical load and shape of deformation of the envelope, the degree of which depends basically on the geometric parameters of the segment. Figures 4; References 7 (Russian).

UDC 624.071:678.067

Load-Bearing Capacity of Multilayer Compounds Tubular Rods of Composite Materials. 1. Rods Compound in Perimeter and Radius

907D0122D Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 1, Jan-Feb 90 pp 85-92

[Article by V. V. Khitrov, V. A. Lapotkin, and A. V. Sukhanov, Institute of Polymer Mechanics, Latvian Academy of Sciences, Riga]

[Abstract] A comparative estimate is presented of the mechanical properties of tubular, longitudinally reinforced monolithic and multilayer compound rods under extension, compression, flexure, tortion and combined loading (proportional flexure and torsion). The extent of utilization of the properties of the initial materials during testing of the tubular compound rods is estimated. Three groups of compound rods were made and studied: two and three-layered rods; one and three-layered rods reinforced with a casing on the inside and a winding on the outside; and monolithic rods. Antiadhesion films were placed between carbon ribbon layers to manufacture multilayer elements. The number of macroscopic layers was found to have virtually no influence on strength and rigidity of the first two groups of rods

with equal total thickness. Monolithic and compound rods fractured in the same manner. The load-bearing capacity of the rods can be improved to approach the mechanical properties of monolithic rods by improving the technology of assembly and by the use of high-strength film adhesives. Figures 2; References 9 (Russian).

UDC 539.4:678+518.5

Optimization of Layered Systems

907D0122E Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 1, Jan-Feb 90 pp 98-104

[Article by Yu. S. Urzhumtsev, A. G. Adamovich, and M. A. Kanibolotskiy, Engineering-Technology Center, Latvian Academy of Sciences, Riga; Inistitute of Physical and Technical Problems of the North Yakutsk Affiliate, Siberian Division, USSR Academy of Sciences, Yakutsk]

[Abstract] The problem of optimizing multilayer systems can be formulated in terms of the theory of optimal control, generating systems of ordinary differential equations. Limiting the set of materials for synthesis of the structure yields a piecewise-constant class of controlling functions with a finite set of values. This article studies the statement of the problem for systems exposed to unsteady mechanical, temperature and electromagnetic fields with limitations on mass and thickness. The Pontryagin maximum principle can be used to decrease the class of materials used in a given structure significantly. The structure of minimum thickness is found to be 45 percent heavier than the structure of minimum mass. The structure of minimum mass is 53 percent thicker than the structure of minimum thickness. As long as thickness limitations are not too great, the optimal panel consists of two relatively light materials. As maximum thickness decreases, a third, heavier material layer appears, its fraction of the total mass increasing with a decrease in maximum thickness allowed. Figures 2; References 7 (Russian).

UDC 539.3:678.074

Iterative Method of Designing Homogeneous and Multilayered Envelopes of Rotation of Highly Elastic Materials

907D0122F Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 1, Jan-Feb 90 pp 109-116

[Article by V. M. Akhundov, "Orbita" Scientific-Production Association, Dnepropetrovsk]

[Abstract] An iterative method is suggested for numerical solution of the problem of axisymmetrical deformation of thin homogeneous and multilayered envelopes of rotation made of highly elastic materials, based on the hypothesis of a compressible perpendicular element. According to this hypothesis, the element retains its straightness and remains perpendicular to the surface, experiencing relative elongation which varies through the thickness of each layer. The variation between stress and strain is nonlinear, determined by the elastic potentials of the layer materials. The method can determine the deformation and thicknesses of the deformed layers in accordance with the distribution of stresses through the thickness coordinate. The effectiveness and reliability of the iterative method suggested are demonstrated in calculations for rubber, rubber-fiber and rubber-layer shells. Figure 1; References 18 (Russian).

UDC 624.071+539.376

New Finite Element for Studying Stability of Three-Layer Rod of Composite Material

907D0122G Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 1, Jan-Feb 90 pp 117-125

[Article by M. M. Kishkilov, Higher Institute of Construction and Architecture, Sofia, Bulgaria]

[Abstract] A method is developed for numerical solution of the problem of stability of a three-layer rod made of a composite material with the properties of linear viscoelasticity. Based on a precise analytic solution and the method of finite elements, a new finite element is constructed with six degrees of freedom. An incremental rigidity matrix is obtained, the elements of which are more complex than when a finite element with eight degrees of freedom is used. The advantage of the new finite element is the decreased number of equations used for its solution and the possibility of producing independent solutions in time and space. Figures 5; References 3 (Russian).

UDC 629.7.023-434.1:539.4.011

Diagnosis of Strength of Spirally Wound Shells and Its Relationship to Composite Mechanics

907D0122H Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 1, Jan-Feb 90 pp 126-131

[Article by S. S. Abramchuk]

[Abstract] In this work, using a spirally wound organic plastic envelope as an example, results are presented from the use of methods of composite mechanics to diagnose the strength of a product. This is facilitated by the strong anisotropy of the elastic and strength properties of a unidirectional shell layer, for which the strength and rigidity in the direction of the reinforcement are one or two orders of magnitude greater than the other characteristics. The effect of cracking of the layers is revealed by measurement of acoustical emissions, which reach their maximum at about 20 percent of the failure pressure. Strength diagnosis requires information on the most informative parameters influencing strength and

deformation, including the strength and deformation properties of the unidirectional layer in the direction of the fiber, the parameters of the reinforcement system and the geometry of the envelope. Estimation of the quality of reinforcing material in circular and spiral layers of products, the volumetric content of fibers in the plastic, their effective strength and deformation at known geometry and loading state allows diagnosis of strength. The correlation factor between the results of diagnosis and actual values of strength is quite high (0.987) confirming the applicability of the diagnosis method. Figures 4; References 27 (Russian).

UDC 620.196.2:621.785:621.774.1:669.15-194.56

Effect of Vacuum Heat-Treatment Practice on Corrosion Resistance of Alloy 06KhN28MDT Centrifugally Cast Tubes

907D0145A Moscow ZASHCHITA METALLOV No 2, Mar-Apr 90 pp 217-222

[Article by L. P. Shchesno, A. G. Pigulevskaya, A. I. Sukhomlin, A. A. Verbitskaya, , V. P. Vlasova, A. M. Babchenko, and A. I. Kistanov, All-Union Scientific-Research and Design and Technology Institute of Tubular-Products Industry]

[Abstract] Austenitic steel 06KhN28MDT, which contains 24% Cr, 28% Ni, 3% Mo and Cu, 0.04% C, and 0 or 1% Ti, was homogenized in a laboratory vacuum furnace at 1250 or 1300°C for periods of time ranging from 12 to 38 hours, during which time CO_2 was added to the furnace for various lengths of time in order to decarburize the steel with the aim of preventing intergranular corrosion in hot sulfuric acid and eliminating the susceptibility to brittle fracture. In the case of Ti-free steel, several combinations of cycles of vacuum and CO_2 treatment at 1250°C resulted in reduction of carbon content to below 0.015%, which was sufficient to prevent brittle fracture and intergranular corrosion. In an industrial furnace the steel was decarburized to as low as 0.012% C by coating it with oxides of the alloying elements prior to the homogenizing anneal. This also eliminated brittle fracture and intergranular corrosion in Ti-free steel. Figures 2; tables 2; references 5: 5 Russian.

UDC 621.039.553.36

Effect of Chemical-Thermal Treatment of Chromium-Containing Steels and Alloys on Their Corrosion Resistance in Nitrogen Tetroxide

907D0145B Moscow ZASHCHITA METALLOV in Russian No 2, Mar-Apr 90 pp 223-228

[Article by V.P. Isakov, A.A. Antonov, and L.V. Zharkova]

[Abstract] A 20-fold increase in corrosion resistance of steel 09Kh16N15M3B and of a 65% Cr iron-chromium alloy in nitrogen tetroxide was obtained by enriching the surface layer with chromium. Chromium-enrichment was achieved by heating the materials in moist hydrogen at 1120 to 1170°K (this oxidizes chromium in the surface layer and allows more chromium to diffuse to the surface) and reducing the chromium oxide in the surface layer with dry hydrogen at 1170°K. The reduction of chromium oxide was followed thermogravimetrically. Auger electron spectrometry, X-ray photoelectron spectrometry, X-ray microanalysis, and scanning electron microscopy were used to study the elemental and phase composition of the surface layer, the distribution of the elements in the surface and subsurface layers, and the morphology of the surface layer. Figures 3; table 1; references 9: 8 Russian, 1 Western.

UDC 620.196.2

Modeling of Corrosion-Electrochemical Behavior of Binary Titanium Alloys

907D0145C Moscow ZASHCHITA METALLOV in Russian No 2, Mar-Apr 90 pp 241-245

[Article by I. V. Kasatkina, N.D. Tomashov, and A. I. Shcherbakov, Physical Chemistry Institute, USSR Academy of Sciences]

[Abstract] Corrosion of binary titanium alloys with nickel, cobalt, molybdenum, and tungsten in 5 N sulfuric acid was simulated by galvanic cells in which titanium acted as anode and the alloying elements, as well as an intermetallic compound Ti2Ni, acted as cathodes. The cathode surface area was 1 cm2, while the anode surface area was varied in such a manner that the ratio (in percent) of the cathode surface area to the the sum of the electrode areas was a whole number. The combined electrode potential and the cell current were calculated from the potential drop across a resistance of 1 ohm. The titanium passivation efficiency of the alloying elements was found to increase in the order W, Mo, Co, Ni, and Ti2Ni. Examination of the cathodic curves of Co, Ni, Mo, and W and the anodic curve of Ti shows that the surface area of these cathodes must greatly exceed the surface area of the titanium anode if titanium is to be passivated. The Ti2Ni cathode is more efficient. Similar results were obtained by computer calculation of the potentials and current intensities. In the case of Ni and Ti2Ni cathodes, when they are sufficiently large to passivate titanium, the combined potentials of the galvanic cells approach the corrosion potentials of these cathodes and their rapid dissolution. Therefore a second alloying element that provides cathodic protection and does not dissolve at corrosion potentials of the passive alloy should be used with nickel. Figures 3; table 1; references 10: 6 Russian, 4 Western.

UDC 620.193

Corrosion-Electrochemical Properties of Oxide-Carbide and Oxide-Nitride Coatings on Titanium Obtained in Electrolyte Plasma

907D0145D Moscow ZASHCHITA METALLOV in Russian No 2, Mar-Apr 90 pp 246-251

[Article by N. D. Tomashov, T. V. Chukalovskaya, I. L. Medova, V. N. Duradzhi, and G. M. Plavnik, Physical Chemistry Institute, USSR Academy of Sciences]

[Abstract] Oxide-carbide and oxide-nitride coatings were produced on titanium by applying a potential difference of about 200 V between a steel cathode and a titanium anode in aqueous electrolytes containing 10% ammonium chloride and 10% acetone (to produce oxides and

carbide) and 20% ammmonium chloride and 20 percent ammonium hydroxide (to produce oxides and nitride). This generated a current density of 1 A/cm$_2$ and heated the titanium anode to 400 to 1200°C, producing a "plasma jacket" on the anode surface. The plasma produced carbon and nitrogen anions (from acetone and ammonium hydroxide, respectively), which were adsorbed by titanium and diffused into it, producing oxide-carbide and oxide-nitride coatings by reacting with titanium. Hardness tests and electrochemical corrosion studies show that both carbide-and nitride-containing coatings substantially increase the hardness of titanium and greatly reduce its corrosion rate (by two orders of magnitude) in 5N sulfuric acid. Figures 3; tables 2; references 11: 10 Russian, 1 Western.

UDC 620.197.665

Comprehensive Assessment of Efficiency of Corrosion Inhibitors

907D0145E Moscow ZASHCHITA METALLOV in Russian No 2, Mar-Apr 90

[Article by M. A. Zubareva, V. M. Shkolnikov, N. A. Litvinova, Zh. Sh. Yerukhimovich, and E. V. Kalinina, All-Union Petroleum-Processing Scientific-Research Institute]

[Abstract] Seven sulfonate soaps used as corrosion-inhibiting additives in corrosion-protection oils were tested for their adsorption, chemisorption, and surfactant properties and for their effectiveness in corrosion protection by various mechanisms. The inhibitors were synthesized from synthetic materials, from petroleum, and from a mixture of the two. The corrosion-protection by various mechanisms was determined by humidity-chamber, sea-water, salt-spray, HBr-, NaCl-, and water-displacement tests. Corrosion-protection properties of five-percent solutions of each corrosion inhibitor in oil by various mechanisms are reported in a table. In general, synthetic sulfonates were found to be the best corrosion inhibitors, the petroleum-derived sulfonates being last. Figure 1; tables 5; references 8: 7 Russian, 1 Western.

UDC 620.191

Predicting Sea-Water Corrosion of Steel From Its Physical and Chemical Properties

907D0145F Moscow ZASHCHITA METALLOV in Russian No 2, Mar-Apr 90 pp 302-305

[Article by B. B. Chernov, Far-East Corrosion Station, Physical Chemistry Institute, USSR Academy of Sciences]

[Abstract] Starting from the knowledge that the rate of corrosion of all low-alloy steels in sea water is practically the same, that it decreases asymptotically with time, and that it depends on oxygen concentration in sea water, on water temperature, and on the diffusion of oxygen through the mineral deposits on steel, equations for the rate of corrosion and corrosion losses are derived from theoretical considerations and corrosion data. The rate of corrosion V at time t is given by $\ln V^2t/C = 16{,}852 - 2{,}358.1/T$. The corrosion loss L at time t is given by $L = 2[\exp(16{,}852 - 2{,}358.1/T)Ct]^{1/2}$, where C is the oxygen concentration in sea water and T is the absolute temperature. The equations are valid only for ocean areas without unusually strong currents, which affect the rate of dissolution of corrosion products. Figure 1; table 1, references 9: 8 Russian, 1 Western.

UDC 620.193

Atmospheric Corrosion of Zinc and Cadmium Coatings in Tropical Climate of Vietnam

907D0145G Moscow ZASHCHITA METALLOV in Russian No 2, Mar-Apr 90 pp 306-309

[Article by Din Vuy Vu, A.A. Mikhaylov, and Tkhi Shan Fam, Tropical Technology Institute, National Center for Scientific Studies, Socialist Republic of Vietnam, and Physical Chemistry Institute, USSR Academy of Sciences]

[Abstract] The results of five-year open-atmosphere exposure tests of electrolytic zinc, cadmium, and chromated zinc and cadmium coatings on carbon steel are reported. The tests were carried out at eight locations differing in climatic conditions and atmospheric chloride and sulfate contents. Figures 8; tables 3; references: 2 Russian.

UDC 669.295.5

Heat Treatment of VT22 Titanium Alloy

907D0131A Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 3, Mar 90 pp 46-49

[Article by V. N. Moiseyev, Yu. I. Zakharov, Yu. G. Krillov, Yu. M. Dolzhanskiy, and T. G. Danilina]

[Abstract] Conventional heat treatment of the VT22 high-strength titanium alloy in an argon-vacuum furnace is analyzed, this process consisting of three stages at successively lower temperature with intermediate deep cooling to room temperature before aging as the third and last stage. For a refinement of known quantitative relations between heat treatment parameters and mechanical characteristics of the alloy or its welded joints, a 2^{5-1}- factorial experiment had been designed with four heat treatment parameters varied as follows: T_1 from 810°C to 850°C, T_2 from 720°C to 780°C, rate of cooling prior to aging v_2 from 3.5°C/min to 14°C/min, and T_3 from 550°C to 650°C. Specimens of the alloy from three different ladles were cut from from forged rods 180-250 mm in diameter. Hollow cylinders with 170 mm inside diameter and 25 mm thick walls were joined by argon-arc welding with nonconsumable electrodes and an SPT-2 wire. Their impact strength was measured within the seam zone, the critical area. A regression analysis of the data on the basis of adequate statistical models has yielded T_1 = 810°C, T_2 = 750°C, v_2 = 8°C/min as the optimum heat treatment resulting in an alloy with ultimate tensile strength of 1115 N/mm ^{2}, 14.8% elongation, 41.2% reduction, 48.1 J/cm^2 overall toughness, and 29.5 J/cm^2 seam toughness. In order to obtain large ingots and welded joints with satisfactory mechanical characteristics by slow cooling at the rate v_2 = 3.5°C/min, it is necessary that the temperatures of heat treatment be T_1 = 850°C, T_2 = 770°C, T_3 = 550-560°C. Sensitivity of the mechanical properties to variation of any three of these parameters and the necessary correction of the fourth, different for each mechanical property targeted, can be calculated upon differentiation of the appropriate regression equation. This has been for correction of the aging temperature to match given T_1, T_2, and v_2. Figures 4.

UDC 669.295:621.785

Change of Lattice Period of -Phase During Isothermal Annealing of Titanium Alloys

907D0131B Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 3, Mar 90 pp 49-52

[Article by M. V. Maltsev and N. V. Petrikova, Gorkiy Polytechnic Institute]

[Abstract] Experimental data on isothermal heat treatment of titanium alloys are analyzed for changes in the β-phase particularly of its lattice period depending on the treatment temperature and time. Alloys of three classes with different β-phase stabilization factors K_β are included in the study: martensitic (α + β) alloys VT6ch (K_β = 0.25), VT3-1 (K_β = 0.8), VT23 (0.8), transition alloy VT30 (K_β = 1.15), and pseudo-β alloy VT15 (K_β = 2.4). Specimens were heated to a temperature 25-50°C below that of complete polymorphous transformation, held at that temperature for 1 h, cooled in furnace at a rate about 3°C/min to various temperatures for isothermal annealing, and then cooled in water. The lattice period of the β-phase was measured on photographs taken with a URS-50IM X-ray camera, with an error not exceeding 0.00015 nm. The annealing temperature was varied over the 650-450°C range and the annealing time was varied over the 1.5-90 h range. Completion of the β → α transformation, indicated by stabilization of the lattice period, is found to longer time at a lower annealing temperature. The normal-temperature equilibrium was not reached by any specimen annealed at higher than normal temperature, an incubation period having possibly preceded continuation of isothermal phase transformation and this period being evidently shortest at 550°C. Mechanical tests revealed no change in hardness of the VT16 alloy after annealing at 550°C and at 500°C, even though the $(200)_\beta$ diffraction peak had narrowed somewhat, α-phase grains evidently begun to form during cooling from the temperature below that of complete polymorphous transformation (800°C for VT16 alloy). Annealing at 450°C was found to increase the hardness slightly. The hardness of the VT15 alloy, meanwhile, had increased after annealing at each temperature, evidently no phase transformation having occurred during cooling to the annealing temperature and more of the β-phase having formed during annealing. Obtaining the largest volume fraction of the β-phase in 1.5 h requires annealing alloys VT15 and VT30 at 600°C, alloys VT3-1, VT23, VT16 at 550°C, and alloy VT6ch at 500°C. Maximum heat resistance of these alloys requires annealing at the lowest possible temperature for a longer time, a lower annealing temperature raising also raising strength and lowering their plasticity while a longer annealing time increases the manufacturing cost. The optimum tradeoff are 500-525°C for alloys VT15 and VT16, 550°C for alloy VT3-1, 525°C for alloys VT23, VT16, and 500°C for alloy VT6ch. Figures 3; references 5.

UDC 661.865.4.001.4

Solid-State Synthesis of Lanthanum Chromite

907D0130A Moscow OGNEUPORY in Russian No 3, Mar 90 pp 9-12

[Article by S. A. Suvorov and A. Yu. Nikiforov, Leningrad Institute of Technology imeni Lensovet]

[Abstract] Synthesis of lanthanum chromite was studied for optimization purposes, this material being used for

high-temperature resistance heater elements. In a vibratory grinding mill with balls made of a hard alloy analytically pure Cr_2O_3 and $CaCO_3$ together with grade LaO-D La_2O_3 were pulverized into the 5-15 μm grain size fraction and thoroughly mixed for 12 h. The mixture was fired in an oxidizing atmosphere. The reaction which took place in several stages yielded a series of $La_{1-x}Ca_xCrO_3$ solid solutions along with pure $LaCrO_3$. Phase analysis of the products in a DRON-2 X-ray diffractometer with a CuK_α-radiation source and with rock crystal as reference substance revealed 1 wt.% $LaCrO_3$. For a more precise quantitative phase analysis, to a stoichiometric (1:1) mixture of La_2O_3 and Cr_2O_3 were added various quantities of $LaCrO_3$ as reference substance. The latter had been synthesized at a temperature of 1673 K, 16 h allowed for the reaction, with mixing after the first 8 h. Chemical analysis based on solubility of CaO and La_2O_3 in 10%HCl, Cr_2O_3 as well as $CaCrO_3$ and $LaCrO_3$ being insoluble in it, followed by treatment with ethyl glycerate and subsequent titration with Trilon B did not reveal any free CaO. End of the reaction was indicated by presence of free La_2O_3 in the residue left by filtration and hardened for 1 h at 1173 K. For an analysis of the phase formation kinetics in that synthesis reaction, 20 experiments necessary for a regression equation were planned with the reaction temperature in varied over the 1273 - 1773 K range and the holding time at each temperature varied up to 6 h. The specimens weighed not more than 10 g, the CaO-equivalent $CaCO_3$ content in the original mixture having been varied from 0 to 4 mol.%. The results indicate that synthesis of pure $LaCrO_3$ comes to a completion in 2 h at 1695 K, β-$Ca(CrO_2)_2$ forming at the same time and solid solutions of the $La_{x-1}Ca_xO_3$ series with $x = 0.25$ or higher with slightly different crystal lattice parameters forming during the next 8 h. Figures 2; tables 2; references 12.

UDC 666.762.5.017:620.172.224

Measurement of Ultimate Tensile Strength of Ceramics in Atmosphere of Combustion Products at Temperatures Up to 2500 K

907D0130B Moscow OGNEUPORY in Russian No 3, Mar 90 pp 18-20

[Article by O. B. Bakunov, Ye. P. Pakhomov, and Yu. I. Chubarov, Institute of Air Transport]

[Abstract] The authors have designed and assembled an apparatus for measuring the mechanical characteristics and specifically the tensile strength of high-temperature ceramic oxides under conditions simulating those in a combustion environment, an atmosphere of combustion products at temperatures within the 1700-2500 K range. Its principal component is an oxyacetylene burner, a tube made of uncut granular zirconia bricks with several jetties along the inside wall for breaking the stream of combustion products. The test specimen, a solid rectangular bar or dumbbell bar with a cavity simulating a black body is freely inserted vertically through two holes in the tube wall. Two metal jaws of a clamp on top hold it in place and from a circular metal clamp at the bottom end are suspended weights which load the specimen in tension, metal clamps being used considering that the temperature of a specimen at its ends projecting outside the burner duct does not exceed 1000 K. Another hole in the tube is provided for insertion of a thermometer. In this apparatus have been tested specimens of 7-day wet-cured zirconia concrete containing 80 wt.% electrically fused ZrO_2 and 20 wt.% cement. Their apparent density and apparent porosity were 4.4-4.6 g/cm^3 and 13-16% respectively. The temperature dependence of their ultimate tensile strength was determined under a load increasing at a rate of 5 kgf/min, the temperature being measured with a "Promin" pyrometer. For comparison were also similarly tested specimens of granular refractory zirconia. Figures 4; references 1.

UDC 669.295.31

Production of High-Purity Titanium Dioxide For Hard-Alloys Industry

907D0129A Moscow TSVETNYYE METALLY in Russian No 3, Mar 90 pp 67-69

[Article by L. G. Terekhova, A. I. Lystsov, V. I. Tsvetkov, and A. N. Myasnoy]

[Abstract] Experimental batches of high-purity titanium dioxide for the hard alloys industry were produced by burning $TiCl_4$ vapor with hot oxygen, by the same method in the same apparatus used for production of titania pigment. The reaction here takes place at temperatures above 1100°C, with a mixture of nitrogen and natural gas being added to the oxygen so as to first separate the reactants and then stabilize the flame. Contamination of the hard-alloy TiO_2 by silicon and aluminum usually added as modifiers the TiO_2 pigment production as well as by other likely impurities was prevented by frequent replacement of the electrodes and the carbon-graphite packing, by chlorination of the fresh packing, by washing the dispenser tanks, the evaporator vat, and the feeder tubes with high-grade titanium tetrachloride, and by cleaning all accessory equipment such as cooler, collector, conveyor. As source materials were used 99.97% pure $TiCl_4$ and 99.5% pure O_2). This was to be 99.6% pure TiO_2 (maximum 0.010% Fe, 0.050% Si, 0.030%Al, 0.005% V, 0.005% Cr, 0.005% Ni, 0.005% Cu, 0.100% Cl) with at least 10.0% of grains in the 1 μm and larger fraction. The process conditions were varied for optimization purposes, all variants having yielded a satisfactory product. Lowering the heat supply to the reaction zone ensured the necessary grain growth. Lowering it to 550 Wh/kg should allow even further grain growth, but lowering it still more may lower the temperature too much so that the flame will break up and the combustion will be incomplete. A preferable alternative would be redesign of the combustion apparatus, most important being a burner in which the $TiCl_4$ and O_2 streams meet at a smaller angle and thus generate a longer flame. Producing 1 kg of hard-alloy TiO_2 should require not more than 2.64 kg $TiCl_4$, 430 nm^3 oxygen, 41 nm^3 nitrogen, and 10 nm^3 natural gas. Figures 1; tables 2.

UDC 621.762.3:620.18.3

Classification of WC Powders For Production of Hard Alloys

907D0129B Moscow TSVETNYYE METALLY in Russian No 3, Mar 90 pp 70-74

[Article by T. B. Gorbacheva, G. L. Krasnova, T. A. Rakoch and I. N. Chaporova]

[Abstract] A comprehensive study of WC powders produced by the $WO_3 \rightarrow T_{red.1}$ $WO_2 \rightarrow T_{red.2}$ $W \rightarrow T_{carb}$ WC was made, tungsten carbide being obtained under 13 different sets of conditions. The temperature of first reduction $T_{red.1}$ was either low (650°C) or high (900°C high), the temperature of second reduction $T_{red.2}$ being raised in steps 800-900-1200°C after first reduction at 650°C and in steps 900-1200°C after first reduction at 900°C. The carbidization temperature T_{carb} was in the second case(With and the temperature of second reduction $T_{red.2}$ was 1400°C after second reduction at 800°C, and it was raised in steps 1400-1800-2200°C after second reduction at 900°C or 1200° C. Data were obtained on the chemical composition (WO_3 and WO_2 content) and on their morphology, the latter including grain size distribution and subgranular structure. The differences between WC powders of the basic two low-$T_{red.1}$ and high-$T_{red.2}$ groups became evident as the carbidization temperature was raised, the grain characteristics changing with a trend toward agglomeration in the first case and remaining the same at some high agglomeration level in the second case. These conclusion are based on measurements of the specific surface, of methanol vapor absorption, and by the Fisher mean-size method, followed by correlation and regression analyses of the data. Defectiveness of the crystal lattice was indicated by broadening of the $(1122)_\alpha$ X-ray diffraction line, that of low-$T_{red.1}$ powders depending more on the carbidization temperature than that of high-$T_{red.1}$ powders and being minimal in all powders after carbidization at 2200°C. As to the chemical composition of these powders, spectrum analysis revealed a lowering of the impurity content after carbidization at a higher temperature. The critical process parameters are thus found to be $T_{red.1}$ and T_{carb} and, with both held constant, $T_{red.2}$ to be adjustable over the 900-1200°C range without an effect on the characteristics of the final powder product. Figures 5; tables 4; references 10.

UDC 586.516:621.77:669.2/.8

Improvement of Standards For Rolled Stock of Nonferrous Metals

907D0129C Moscow TSVETNYYE METALLY in Russian No 3, Mar 90 pp 95-96

[Article by Yu. M. Leybov and V. A. Chervonenkov]

[Abstract] Revision of existing Government Standards for rolled stock of nonferrous metals is proposed, in view of their inadequacy as well as lesser flexibility as compared with standards applicable in other countries (USA, France, West Germany, Japan). Taking into account the procedural complexity of revising a Government Standard and in order to facilitate the process, the requirements which rolled stock of nonferrous metals must meet are subdivided into three categories: I) basic technical ones, II) supplementary technical one including contractual ones, III) supplementary technical ones negotiated by user and producer which have not been specified or may differ from those specified in the existing standards as well as terms of delivery. The third category includes intermediate thickness, width, and length to be maintained during the production process, maximum permissible deviations from nominal thickness and width, surface shape and finish, mechanical properties, and selection of which mechanical indicator may deviate from the applicable standard, and specifications regarding coils, stacks, or other delivery mode. The standards revised accordingly would make it possible to differentiate between products made of rolled stock and to thus satisfy all users, would enable each producer to independently resolve problems regarding adaptation of technical standards, would reduce the volume of documentation by reducing the number of constraints, would make quality by statistical and nondestructive methods more widespread, and would make it possible to select packaging and transportation best suited for an given type of rolled stock.

[UDC [621.777.044.2+621.791.76:621.7.042]: 621.315.612

Dynamic Compaction of Ceramic-Base Composite Materials

907D0128G Kiev AVTOMATICHESKAYA SVARKA in Russian No 3, Mar 90 pp 40-42, 49

[Article by A. A. Betman, doctor of technical sciences, O. G. Yepanchintsev, candidate of physical and mathematical sciences, and Yu. I. Zvezdin, doctor of technical sciences, Scientific-Industrial Association Central Scientific Research Institute of Machine Manufacturing Technology, A. A. Deribas, doctor of physical and mathematical sciences, V. F. Nesterenko, doctor of physical and mathematical sciences, and S. A. Pershin, engineer, Special Design Office for Hydraulic Impact Equipment Engineering, Siberian Department, USSR Academy of Sciences, V. D. Natsik, doctor of physical and mathematical sciences, and Ye. D. Tabachnikova, candidate of physical and mathematical sciences, Institute of Low-Temperature Engineering Physics, UkSSR Academy of Sciences]

[Abstract] Compaction of powder by explosion pressing was studied on $YBa_2Cu_3O_{7-d}$ superconductor ceramics with a critical temperature of 90 K or higher and a critical current density of 375 A/cm^2. Cylinder and ring

compacts of this material were inserted into metal tubes and joined to the latter on the inside so as to form composite windings or were used for forming metal-ceramic and metal-ceramic-metal face joints. For the metal component were selected aluminum, nickel, copper, and stainless steel. Microstructural examination of face joints produced by compaction of ceramic and metal powders revealed an erose contact surface, probably due to Rayleigh-Taylor instability of the metal powder and ceramic powder interface triggered by passage of a shock wave. Adiabatic shear was detected in joints with stainless steel, probably due to tangential rupture of the shock wavefront. The ceramic component had after compaction a density of 5.86 g/cm^3 and a microhardness of 3100 N/mm^2, the latter so high because of the large number of induced defects. Standard annealing heat treatment lowered the microhardness to 2500 N/mm^2 without appreciably changing the density. Joints produced under an impact pressure of 2.9 GPa were tested under a mechanical load deforming the ceramic, the weaker component, at a rate of 0.2 mm/min. At a 4.2 K temperature the ceramic began to crack under a stress of 90 MPa and crushed completely under a stress of 207 MPa. Its ultimate strength decreased to 154 MPa at 77 K and to 139 K at 300 K. The same ceramic produced by static compaction after standard hot sintering crushed under a stress of 275 MPa at 89 K, its critical superconducting transition temperature and under stress of 340 MPa at 300 K. Figures 3; references 7.

UDC 620.178.3.699.255

Corrosion Cracking of (Alpha + Beta)-Titanium Alloys As a Function of Temperature-Time Parameters of Heat and Plastic Treatment

907D0124A Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 26 No 1, Jan Feb 90 pp 118-120

[Article by Yu. D. Khesin, L. A. Ivanova, A. I. Igolkin, and S. N. Petrov]

[Abstract] A study is made of the influence of heat and heat-plastic treatment modes on corrosion cracking of titanium alloys. Studies were performed on VT-6 alloy containing a typical isomorphic beta-stabilizer, vanadium and, for comparison, VT-5 alloy without stabilizer. Ingots produced by double vacuum-arc remelting were forged under various conditions into bars 300 mm in diameter. Mechanical properties were determined and short-cycle tests performed on notched tensile specimens in one percent HCl with nominal stresses of 0.97 $\sigma_{0.2}$. It was found that in all cases, VT-6 had a significantly lower tendency toward corrosion cracking than VT-5. The tendency toward corrosion cracking increased after annealing in the two-phase temperature interval of 1073-1273°K. At the polymorphous conversion point the short-cycle durability in water is restored. The variation of corrosion-cracking sensitivity upon aging with prior heat-treatment mode indicates that rapid cooling of the alloy after annealing in the beta area provides greater short-cycle durability in a corrosive medium. The tests confirmed that when alpha-titanium alloys contain isomorphic beta-stabilizing elements the provoking effect of aging is significantly reduced. The chemical composition of the basic solid solution, determined in part by the prehistory of processing, is an important factor in the tendency of titanium alloys toward corrosion cracking. Figures 4; References 2 (Western)

UDC 678.01:641.123.7

Acoustic Emission in Composite and Ceramic Materials

907D0132A Kiev TEKHNICHESKAYA DIAGNOSTIKA I NERAZRUSHAYUSHCHIY KONTROL in Russian No 1, Jan 90 pp 41-44

[Article by O. V. Lyashenko, V. M. Perga, and I. N. Salivonov, Kiev State University imeni T. G. Shevchenko]

[Abstract] An experimental study of acoustic emission in composite materials under load was made, the object being to analyze the amplitude distribution of acoustic emission signals for identification of their source. As a model material was selected the Cu-ED14 composite consisting of copper fibers in an epoxy matrix. Specimens of this material were loaded cyclically till fracture, while an AI-256 pulse analyzer recorded signals with amplitudes from the 63 dB threshold level up relative to 10 μV (analyzer gain 59 dB, noise level 3-4 dB). The four peaks corresponding to 68-70 dB, 73-75 dB, 78- 79 dB, and 83-87 dB signals on the histograms were, with the aid of special tests, identified as acoustic emission during fiber deformation prior to fracture (first two peaks), during fiber fracture, and during rupture of the adhesive fiber-matrix bond respectively. The higher amplitude (83-87 dB) of signals generated during rupture of that adhesive bond indicates that this bond is stronger than the fibers, the narrowness of this peak indicating that rupture of this bond is a threshold-having process. An analysis of data on acoustic emission in other composite materials with variable filler concentration such as quartz sand in ED20 epoxy without or with antiadhesive (dimethyl dichlorosilane) and in ceramic materials such as ferroelectric $BaTiO_3$ without or with Ce impurity indicates that acoustic emission can serve as indicator of fracture by various mechanisms and of phase transition. In the latter case it can be used as an effective method of determining the Curie temperature accurately within 2-3°. Figures 4; references 12.

UDC 621.791.052.08:620.179.16

Testing Alloy Steel at Low Temperatures by Method of Acoustic Emission

907D0132B Kiev TEKHNICHESKAYA DIAGNOSTIKA I NERAZRUSHAYUSHCHIY KONTROL in Russian No 1, Jan 90 pp 68-71

[Article by I. V. Parkhomenko, M. A. Yaremenko, Yu. V. Zhbanov, V. I. Kalemanov, A. P. Kozub, S. A. Voronin,

and V. P. Starikov, Institute of Electric Welding imeni Ye. O. Paton, UkSSR Academy of Sciences, Kiev]

[Abstract] Testing alloy steels at low temperatures by the method of acoustic emission method was studied at the Institute of Electric Welding (UkSSR Academy of Sciences), using a 4-channel "Defectophon" recording instrument made in Hungary and an IBM personal computer. As a typical alloy steel was selected the 12Cr18Ni10Ti grade. Testing was done at 293 K room temperature and at 77K temperature in liquid nitrogen, the AK-45 fixture developed at the Institute of Colloid Chemistry and Water Chemistry (UkSSR Academy of Sciences) having been selected for holding a linear array of four transducers against the surface of steel bar specimens. Signals of 1 V amplitude and 1.5 μs duration were transmitted from an electric pulse generator to an acoustic-emission simulator at a repetition rate of 10 Hz. Bar specimens of steel with a 400 m gage length and a 7 x 27 mm^2 active cross-section area were tested under tension, some specimens having nondefective transverse butt-welding seams and others having defective ones. Deformation was localized within the seam zone, by means of a stress concentrator with a 20 mm radius, and the four transducers lined up along a bar specimen were able to locate the source of acoustic emission. In the specimens with nondefective seams at 77 K (ultimate tensile strength 910 MPa) the acoustic activity, measured by the number of pulses per second, was found to be maximum under stresses within the 180-750 MPa range and the amplitude of acoustic emission signals to be maximum prior to fracture. In the specimens with underwelds at 77 K (ultimate tensile strength 493 MPa) the acoustic activity was maximum under stresses within the 110-290 MPa range, much before fracture. Figures 3; tables 1; references 3.

UDC [621.791.4.052:539.378.3]:621.315.612

Characteristics of Joint Formation During Diffusion Welding of Corundum Ceramic With Aluminum Filler

907D0128A Kiev AVTOMATICHESKAYA SVARKA in Russian No 3, Mar 90 pp 20-24

[Article by L. N. Larikov, doctor of technical sciences, and M. N. Belyakova, candidate of technical sciences, Institute of Metal Physics, UkSSR Academy of Sciences, V. N. Zamkov, doctor of technical sciences, L. S. Kireyev, candidate of technical sciences, M.M. Struina, engineer, and N. A. Chaban, engineer, Institute of Electric Welding imeni Ye.O. Paton, UkSSR Academy of Sciences]

[Abstract] An experimental study of diffusion welding of ceramic with use of an aluminum filler was made, of concern being the chemical and phase transformations within the welding zone which lead to formation of the a joint. Specimens of VK94-1 corundum ceramic were welded using commercial-grade AD-1 aluminum for 0.03-0.05 mm thick layers deposited on the faying surfaces by vacuum evaporation, 0.1 mm thick layers "pasted on" by quasi-friction welding, and 0.4 mm or 0.8 mm thick washers. Cylinders 15 mm in diameter and 15 mm high were thus butt welded together in a P-115 machine, with the temperature raised in steps over the 673-723-773-823-873-923 K range and the pressure raised in steps over the 30-40-60-80-90 MPa range, allowing appropriately 30 min, 15 min, five min, or one min for the process. Metallographical examination of the joints revealed plastic deformation of the aluminum fillers only, examination under optical and scanning microscopes as well as X-ray microanalysis having revealed no diffusion zones at the ceramic-aluminum interfaces. The results of fracture analysis and the calculated temperature dependence of the Gibbs reaction energy up to and beyond the melting point of aluminum indicate that dynamic recrystallization of aluminum at temperatures above 773 K accelerates the establishment of physical contact and chemical bonding, formation of the joint not being governed by interaction of aluminum and the glassy ceramic phase. The optimum conditions for such a diffusion welding were found to be 873-923 K, 30-90 MPa, and five-15 min. Figures 5; references 18.

UDC [621.791.4:539.378.3:681.2]:621.315.612:669.715

Diffusion Welding of Alumina Ceramic With Zn-Al or Al-Cu Alloy Fillers

907D0128B Kiev AVTOMATICHESKAYA SVARKA in Russian No 3, Mar 90 pp 24-27

[Article by L. S. Kireyev, candidate of technical sciences, M. M. Struina, engineer, and N. A. Chaban, engineer, Institute of Electric Welding imeni Ye. O. Paton, UkSSR Academy of Sciences, L. N. Larikov, doctor of technical sciences, and M. N. Belyakova, candidate of technical sciences, Institute of Metal Physics, UkSSR Academy of Sciences]

[Abstract] An experiment has demonstrated that, although the optimum temperature for conventional diffusion welding of alumina ceramic with an aluminum filler is 620°C, it is possible to lower the temperature to 450°C and thus satisfy the applicable requirements of the electronics industry by using fillers made of a Zr-Al or Al-Cu alloy rather than of commercial aluminum. Cylinders 12 mm in diameter and 10 mm high were welded in a special fixture, after both faying surfaces and the filler had been polished by etching and then dried. A satisfactory joint with neither pores nor underwelds and with a maximum leakage through the seam below 1.33×10^{-5} mm^3 could be obtained with an aluminum or AlMg-6 filler at 550°C, but it required a pressure of at least 40 MPa even with the welding time extended to 90 min. With fillers made of the more deformable Zn + 22 wt.% Al alloy or Al + 9.5 wt.% Cu alloy, both welding temperature and pressure could be lowered to 450°C and 10 MPa respectively. The quality of joints produced with 0.8-1.0 mm thick fillers of either alloy has been confirmed by the results of comprehensive tests including vibration, heat, and repetitive momentary impacts as well as by microstructural examination of fractured surfaces, the latter indicating a more ductile fracture than that of joints produced with an aluminum filler. Use of an Al-Zn filler is limited, however, because zinc evaporates during welding and its vapor then condenses on the surfaces of the joined parts when they are cooled. Figures 3; references 3.

UDC [621.791.7:666.11.037.578.2]:537.12

Physical Processes During Silicon-to-Glass Welding in Electric Field

907D0128C Kiev AVTOMATICHESKAYA SVARKA in Russian No 3, Mar 90 pp 27 31

[Article by N. N. Khomenko, candidate of technical sciences, Kiev Polytechnic Institute, Chernigov branch]

[Abstract] Electric welding of silicon to glass in the manufacture of semiconductor devices such as pressure transducers is analyzed on the basis of a physical model of this process: a silicon layer above a glass layer resting on a heater plate, the silicon layer under the positive electrode of a source of high-voltage pulses and the heater plate connected to the negative terminal of that source while being energized by an a.c. transformer. The appearance of Newtons rings indicates a thin air gap between the two layers and changes in this interference pattern indicate changes which occur as a solid contact between the two layers is established. Electric discharge and electrolysis are the basic two process considered here, both constraining the the welding process and limiting its parameters which include the temperature. The rate at which the current drops, after it has built up during the initial transient period and the temperature

has stabilized, is shown to be a very sensitive and thus reliable indicator of the welding process performance. The trend of the current-time curve, which determines the necessary welding time, is shown to depend on the voltage amplitude and the pulse form as well as on the glass composition and the method of mechanical or chemical surface treatment. The magnitude of electrostatic forces and the flashover voltage under which glass breaks down are, meanwhile, known to depend not only on the glass composition and the surface treatment but also on the temperature and the air humidity. The analysis is supported by data on 10 grades of glass and data correlating voltage, welding time, electric charge, and joint strength at a typical welding temperature of 673 K. Figures 6; table 2; references 4.

UDC 621.791.76:[621.7.044:621.3.015.53]:621.315.612

Electric Conductor-Explosion Welding of Ceramics

907D0128D Kiev AVTOMATICHESKAYA SVARKA in Russian No 3, Mar 90 pp 32-36

[Article by K. A. Yushchenko, doctor of technical sciences, V. S. Nesmikh, candidate of technical sciences, I. V. Dubovetskiy, engineer, and I. V. Kushchenko, engineer, Institute of Electric Welding imeni Ye. O. Paton, UkSSR Academy of Sciences]

[Abstract] An experimental study of electric discharge-pulse welding of ceramics was made concerning the characteristics of joints produced by this method and the waveform of the discharge current as criteria of the welding process performance. The laboratory apparatus consisted of an adjustable capacitor bank, a charging circuit, a high-voltage discharge circuit with two electrodes and voltage control, and a compressor with pressure control. The method was tested on Si_3N_4 ceramic produced by sintering and hot pressing, on SiC ceramic produced by hot pressing, on various oxide ceramics, and on various glasses. Specimens of these materials, 25 mm long and 8 x 10 mm^2 in cross-section with a class 2.5 μm surface roughness, were welded into T-bars. The process was regulated by varying the capacitor size over the 10-100 μF range, the discharger voltage over the 1-10 kV range, and the pressure up to 20 MPa. Also the resistance and the inductance of the discharge circuit were varied. Explosion of 10-100 μm thick Ti, Ni, Cu, Zr, Ta filler foils was triggered by electrical breakdown. Oscillograms of the discharge current and the microstructure of ceramic surface metallized upon explosion of the filler foil indicate that this welding method is satisfactory for ceramic dielectrics, the determining factor being the initial current rise which ends with a sudden restoration of electrical conductivity in the discharge gap. Shunt discharge, which draws some input energy away from the welding zone, has been found to occur under certain conditions. Figures 5; references 4.

UDC [621.791.4:621.777.982]:621.315.612

Welding of Si_3N_4 Ceramic By Hot Pressing

907D0128E Kiev AVTOMATICHESKAYA SVARKA in Russian No 3, Mar 90 pp 36-39

[Article by T. V. Shevchuk, candidate of technical sciences, T. N. Kushnareva, engineer, and G. N. Gordan, candidate of technical sciences, Institute of Electric Welding imeni Ye. O. Paton, UkSSR Academy of Sciences, V. A. Kotko, engineer, and O. A. Babiy, engineer, Institute of Problems in Materials Sciences, UkSSR Academy of Sciences]

[Abstract] Welding of Si_3N_4 ceramic by hot pressing, with a water suspension of sialon powder (80 wt.% Si_3N_4 + 10 wt.% Al_2O_3 + 10 wt.% AlN) and up to 10 wt.% CaO activator pasted on the faying surfaces as filler, was tested on specimens 20 mm long and 12x12 mm^2 in cross-section. Such bars were welded together in a vacuum of 0.02 Pa at a temperature within 1500-1530°C under a pressure of 40 MPa, with isothermal holding for 10-15 min. The joints were examined metallographically under a "Neophot" optical microscope, in an X-ray spectrum microanalyzer with an electronic probe, and under a JEM-100CX high-resolution analytical electron microscope with a "Link 860/500" local X-ray spectrum analyzer. Microhardness was measured with a "Leko M-400" tester. The welding seams were found to be 150-200 μm wide interlayers consisting of wide porous segments with a microhardness of 3600-4700 N/mm^2 and narrow segments along the boundary with the parent material, almost as dense as the latter so as to be hardly distinguishable from it, with a microhardness of 17,000-20,000 mm^2. While the porous segments had a high aluminum and calcium content, the dense segments contained principally Si_3N_4 grains of one size fraction with hardly any traces of aluminum and calcium. Such a nonhomogeneity of welding seams had affected the flexural strength of the joints, porous segments breaking under loads of 80-220 MPa and dense segments breaking under loads of 250-300 MPa, the strength of the parent metal being 300-400 MPa. Figures 6, references 2.

UDC 621.791.3.002:[621.315.612:546.3]

Brazing Si_3N_4 Ceramic to Metals

907D0128F Kiev AVTOMATICHESKAYA SVARKA in Russian No 3, Mar 90 pp 39-40

[Article by V. K. Kolesnikov, candidate of technical sciences, N. A. Bareskov, candidate of technical sciences, A. F. Belkov, candidate of technical sciences, and I. L. Pozdnyakova, engineer, Scientific-Industrial Association 'Kompozit' (Composite), Kaliningrad (Moscow Oblast)

[Abstract] In an experimental feasibility study disks of structural Si_3N_4 ceramic were brazed to disks of

12Cr18Ni10Ti steel, titanium, niobium, and molybdenum. As filler material were used copper, silver, and platinum-nickel solders, all containing titanium or zirconium as activator. Brazing was done in a vacuum furnace under a residual pressure of 0.066 Pa, with the temperature varied over the 960-1200°C range and the holding time varied from five min to 15 min. Metallographical examination and the results of mechanical tests indicate that copper and silver solders with up to 20 wt.% Ti content yield the best joints. All joints except those with molybdenum were found to crack during cooling, however, evidently because of tensile stresses built up owing the large difference between linear thermal expansion of the ceramic and the other metals. A special dovetail joint was subsequently designed and successfully tested in which compressive stresses build up during cooling and prevented cracking. Figures 3.

UDC 661.11.016.2:678.046.346

Physical-Chemical Processes in Hollow Glass Microsphere Technology

907D0121A Moscow STEKLO I KERAMIKA in Russian No 3, Mar 90 pp 9-10

[Article by V. V. Budov, Candidate of Technical Sciences, Moscow Institute of Chemical Technology imeni D. I. Mendeleyev]

[Abstract] The physical and chemical process which form the basis of most known methods of producing hollow microscopic spheres are discussed. In all known methods, the motive force of the process of converting solid glass particles to hollow microscopic spheres is thermal dissociation of oxygen compounds of sulfur dissolved in the glass. The major source of sulfur trioxide is sodium sulfate. An equation is presented which expresses the basic physical-chemical processes employed by most methods of manufacturing hollow glass microspheres: $O^{2-} + SO_2 + \frac{1}{2} O_2 \rightarrow O^{2-} + SO_3 \rightarrow SO_4^{2-}$. For a selected glass composition, synthesized under oxidizing conditions at not over 1400°C, the required SO_3 concentration in the glass depends primarily on the quantity of sulfate in the charge. The hollow spheres are formed by feeding the microscopic powdered glass into a gas stream heated to 1000-1500°C under conditions favoring thermal dissociation of the dissolved SO_3 in the glass. References 3: 1 Russian, 2 Western.

UDC 621.375.826:666.3

Laser Technologies for Processing Ceramic Materials (Review)

907D0121C Moscow STEKLO I KERAMIKA in Russian No 3, Mar 90 pp 14-16

[Article by Ye. M. Markov, Engineer, Yu. I. Voronezhtsev, and V. A. Goldade, Candidates of Technical Sciences, Institute of Metal-Polymer System Mechanics, Belorussian Academy of Sciences]

[Abstract] A review is presented of the literature on laser technologies for the manufacture of ceramic products, films and coatings. Existing technologies for processing of ceramics by laser radiation are subdivided into three groups: production of ceramic coatings on products of metal and other materials such as glass; surface treatment of finished ceramic products; and manufacture of ceramic products and intermediates. A block diagram illustrates the relationship of various processes in these three groups. The products very briefly discussed include processing of coatings of ceramic materials, metallic materials and polymer materials, processing of the surfaces of coatings, slip surfacing and chemical modification of surfaces, gas-phase precipitation of coatings, drawing from melts, production of dispersed particles, working of apertures and slots, cutting and scribing, thermal cracking, application of conducting sectors and layers and marking. Laser working is said to be most promising for production of ceramic coatings and modification of the surface states of finished ceramic products. As laser technologies are further improved, methods must be developed to adjust the parameters of the laser radiation to the changing charcteristics of the ceramic product. This will require the use of lasers with adjustible wavelength and programmable pulse lasers operating with systems to monitor the status of the product being worked. The use of physical fields simultaneously with laser radiation is also promising. These methods can regulate the structure of the material layers worked and give the material the desired properties. References 19: 13 Russian, 16 Western.

UDC 666.762:539.32

Elastic Properties of Metal Ceramic Based on Tungsten Monocarbide at Low Temperatures

907D0121D Moscow STEKLO I KERAMIKA in Russian No 3, Mar 90 pp 20-21

[Article by V. L. Ulyanov, Candidate of Physical-Mathematical Sciences, A. A. Botaki, V. P. Nesterenko, Engineers, and I. P. Chernov, Doctor of Physical-Mathematical Sciences, Tomsk Polytechnical Institute imeni S. M. Kirov]

[Abstract] A study was made of changes in the elastic properties of the metal ceramics VK-6, VK-8, VK-10, VK-15 and VK-20 in the 100-295 K temperature interval. The chemical composition of the metal ceramics ranged from 94 percent WC-6 percent Co to 80 percent WC-20 percent Co; the phase composition consisted of tungsten carbide WC plus a solid solution of WC-Co. Elastic properties were studied by the pulse echo method and the resonant method using a piezoelectric vibrator. The studies show that the dimensions of WC grains varied from 2.5 to 5.0 μm, with hexagonal structure with parameters $a = (2.905 - 2.907) 10^{-10}$ m, $c = (2.837 - 2.838) 10^{-10}$ m, while the cobalt had a face-centered cubic structure with lattice constant $a = (3.562 - 3.565) 10^{-10}$ m. VK ceramics were found to have a

characteristic monotonic decrease in elasticity moduli E and G with increasing temperature and increasing cobalt content. The results can be used to estimate the elastic and strength characteritics of ceramic materials used in low-temperature equipment. References 6 (Russian).

UDC 666.762.45

Evolution of $MgCr_2O_4$-Ceramic Structure and Phase Content

907D0120A Moscow STEKLO I KERAMIKA in Russian No 2, Feb 90 pp 21-23

[Article by V. Kh. Kuliyev, candidate of technical sciences, Scientific-Industrial Association 'Silikatobeton' (Silicates and Reinforced Concrete), and R. Ya. Popilskiy (deceased), doctor of technical sciences, Moscow Institute of Chemical Technology imeni D. I. Mendeleyev]

[Abstract] Synthesis of MgO and Cr_2O_3 oxides with various combinations of grain size fractions during the sintering process was studied in an experiment with already sintered chromium oxide having an apparent density of 4.48 g/cm^3 and an apparent porosity of 10.5%, analytically pure chromium oxide, and PE-IK periclase. The mixtures were heated at a rate of 3°C/min to a final temperature of 1800°C in a special apparatus including a dilatometer for measuring the linear dimensions of the compacts during the process. Structurization and evolution of the phase content were monitored by X-ray diffraction measurements and petrographical analysis, specimens having been cooled to various temperatures corresponding to various stages of their synthesis. The specimen produced from a dispersion of 25.49 wt.% sintered chromium oxide and 13.73 wt.% magnesium oxide in 60.78 wt.% Cr_2O_3 matrix consisting of grains in the 0.25-0.40 mm size fraction was found to have the highest apparent density of 3.79 g/cm^3 and the lowest apparent porosity of 4%, after the binder had been burnt out. The mechanical characteristics of all six specimens did not differ appreciably, a flexural strength of 35-49 MPa being adequate for refractory ceramic. Figures 4; tables 2; references 3.

UDC 666.192.2

Strength of Quartz Ceramic After Thermal Cycling

907D0120B Moscow STEKLO I KERAMIKA No 2, Feb 90 pp 25-27

[Article by A. M. Akhyan, engineer]

[Abstract] Considering that the thermal stability of quartz ceramic is so high as not to be measurable by the conventional method used on refractory materials, it was intentionally lowered by rise and drop of temperature in the course of cyclic annealing-quenching treatment. The thermal stability was then estimated on the basis of the residual strength. Five specimens for such a test were produced by casting dross into gypsum molds, dross having been obtained from transparent quartz glass for three specimens, from transparent quartz glass containing 8-10 wt.% TiO_2 for one specimen, and from synthetic silica for one specimen. The source materials, with a different moisture content each, had been ground to different grain size fractions either in one stage or in two stages. The specimens, all 75 mm long rods 15 mm in diameter, were fired at 1200°C and at 1250°C as cast and after 2, 4, 6, 8 h stabilization periods. Prior stabilization of the castings increased their strength after calcination at 1200°C, longer stabilization resulting in a higher strength. The strength of castings calcined at 1250°C was lower than that of the other ones, but was not influenced by prior stabilization. Three "heating to 1100°C - heating to 1200°C - quenching in water" cycles lowered the strength of all specimens appreciably, that of the finer specimens (from dross produced by grinding in two stages) more severely up to fracture in test. Heating to 1200°C and holding for 30 min at that temperature before slow cooling in the furnace made did not appreciably change the strength of the specimens. The results of this study reveal no definite pattern in which hot annealing influences the strength of this ceramic material, undetectable defectiveness probably playing a role here, but they indicate that stabilization after casting is probably the principal factor contributing to its strength. Figures 1; tables 4.

UDC 666.192.2

Silica-Phosphate Quartz Ceramic

907D0120C Moscow STEKLO I KERAMIKA in Russian No 2, Feb 90 pp 27-28

[Article by M. T. Melnik, doctor of technical sciences, and Nguen Din Ngi, engineer, Kharkov Institute of Civil Engineers]

[Abstract] An experimental study of acid-resistant silica-phosphate materials, ground quartz sand with small addition of orthophosphoric acid, revealed the dependence of their mechanical and chemical properties on their composition and on the calcination temperature. Mixtures of fine quartz sand with a specific surface of 4000-5000 cm^2/g and orthophosphoric acid were thoroughly homogenized into four batches with 6, 8, 10, 12 wt.% P_2O_5 respectively. Each batch was subsequently cast under a 70 MPa pressure into four cylindrical specimens 20 mm in diameter and 20 mm long. After desiccation of all specimens at a 110°C temperature, one specimen of each batch was heated to 1000°C, 1100°C, 1200°C, 1250°C respectively, within 4 h, then cooled to 500-600°C within 3 h, and finally cooled to 50-60°C within 5-6 h. Following this firing process, the best specimens of each batch were selected for measurement of apparent density, apparent porosity, acid resistance, and water absorption. The data indicate that the compressive strength of the material increases when the

H_3PO_4 content is increased and the firing temperature is raised, because more of the $SiO_2.P_2O_5$ can then form. However, firing at 1150°C or higher temperatures will vaporize the phosphoric oxide and thus increase the porosity of the product. Acid resistance was measured in the three most aggressive media: 30% HNO_3, 33% H_2SO_4, and 50% H_3PO_4. Most resistant to all three acids was found to be the specimens with 8-10 wt.% P_2O_5 fired at 1200°C, likewise owing to to the large amount of that $SiO_2.P_2O_5$ phase filling the interstices between sand grains and covering the latter with a protective film. Tables 1.

UDC 666.762:539.32

Radiative Changes in Young's Modulus of Electroceramics

907D0120D Moscow STEKLO I KERAMIKA No 2, Feb 90 pp 19-20

[Article by V.L. Ulyanov, candidate of physical and mathematical sciences, and E.V. Pozdeyeva, candidate of technical sciences, Tomsk Polytechnic Institute imeni S.M. Kirov]

[Abstract] The effect of neutron bombardment on Young's modulus of electroceramics and the attendant dependence of that modulus on the neutron fluence are established on the basis of experimental data, measurements having been made with a piezoelectric vibrator by the resonance method. The velocity of longitudinal elastic waves in such a material as well as its modulus of elasticity were measured at temperatures of 295 K, 200 K, 100 K before and after bombardment with neutron fluxes of 1.2×10^{19} m^{-2} and 1.73×10^{22} m^{-2} density. Five materials were tested: alumina grade UF-46, high-alumina grades MK and GB-7, steatite grades SK-1 and SNTs. Considering that the relative change in volume is equal to the ratio of the concentration of radiative defects to the original concentration of point defects, the dependence of Young's modulus E on the neutron fluence Φ is estimated theoretically on the basis of an algebraic equation for E as a function of the relative change in volume and a differential equation for the rate of change of the radiative defects concentration. The latter equation has two terms on the right-hand side, one representing interaction of incident neutrons with nuclei of atoms in the ceramic material and one representing diffusion of radiative defects as well as their recombination with vacancies in the material. Tables 2; references 8.

UDC 666.189 211

Alkali Glass for Fiber Manufacture

907D0127B Moscow STEKLO I KERAMIKA in Russian No 11, Nov 89 pp 12-13

[Article by S. A. Zaytseva, candidate of chemical sciences, Yu. I. Kolesov, candidate of technical sciences, and S. Z. Volskaya, candidate of technical sciences, Scientific-Industrial Association 'Stekloplastik' (Glass-Plastic)]

[Abstract] A fiber glass has been developed which is both acid-resistant and water-resistant, the essential requirements being a high SiO_2 content of at least 60 wt.%, a high Na_2O and Li_2O content, addition of CaO and ZnO, small amounts of B_2O_3, Al_2O_3, MnO, Fe_2O_3, SnO_2, and inclusion of oxides insoluble in acids. Experimental glasses of at least 30 different compositions within the 61.0 - 67.0 wt.% SiO_2 + 10.0 - 14.0 wt.% CaO + 3.6 - 4.5 wt.% MgO + 2.0 - 2.5 wt.% Al_2O_3 + 11.0 - 14.0 wt.% (Na_2O,Li_2O) + 2.0 - 8.0 wt.% ZrO_2 + 0.2 - 5.0 wt.% TiO_2 range were founded in platinum crucibles. The glasses containing 11.5 - 12.0 wt.% Na_2O and 0.2 wt.% TiO_2, with SiO_2 partly replaced by 2.0 - 5.0 wt.% Al_2O_3 and 2.0 - 8.0 wt.% ZrO_2 were tested not only for chemical stability in pure water and in 1.0 N HCl but also for determining the temperature at which crystallization begins, the dependence of these three key characteristics on the amount of SiO_2 replacement thus having been established as a basis for selection of the optimum glass grades. Further tests performed on the two glasses which begin to crystallize above 1200°C have yielded the temperature corresponding to their melt viscosity of 1000 dPa.s, the curing temperature range, and the optimum temperature range for fiber drawing. These glasses, their Fe_2O_3 content limited to 0.4 wt.%, are designated as grades SP-38 and SP-93 having a 52-72 times higher resistance to HCl and a 2-4 times higher resistance to NaOH than the commercial grade E containing 14.5-15.1 wt.% Al_2O_3 + 0.4 wt.% Fe_2O_3 + 9.5-10.5 wt.% B_2O_3. Figures 2; tables 2.

UDC 666.3-127

Ceramic Diaphragm For Electrolysis

907D0127F Moscow STEKLO I KERAMIKA in Russian No 11, Nov 89 pp 23-24

[Article by S. A. Polyakov, candidate of technical sciences, and S. A. Belmozhin, engineer, All-Union Fireclay Scientific Research Institute, Volzhsk branch]

[Abstract] A ceramic diaphragm for electrolyzers has been developed which ensures more precise separation and thus higher purity of the products than do diaphragms made of water-proof canvas, asbestos cloth, or porous polyethylene. The material for this new diaphragm consists of abrasive grindstone grains embedded in a ceramic binder with a temporary bonding agent. Together with this formulation has also been developed a diaphragm manufacturing process which includes forming, drying and firing. Tests performed at the Kazan Institute of Chemical Technology on 2 mm thick and 120x180 mm^2 large diaphragms have yielded a flexural strength of 2-3 MPa, the material having a density of 2.1-2.3 g/cm^3 and a porosity of 40 - 45%. They were tested in catholytes with a pH from 9.45 to 12.20 and in

anolytes with a pH from 0.80 to 3.50 at oxidation-reduction potentials of -340-(-900) mV and 130-1200 mV respectively, also for activation with currents of 0.2-3.0 A at voltages of 40-80 V and temperatures of 20-50°C for five-10 min. An outstanding advantage of these diaphragms is that their permeability can be varied and that their material can be reconstituted after long service. Tables 1.

UDC 666.192.2:539.4

Strength of Quartz Ceramic

907D0127G Moscow STEKLO I KERAMIKA in Russian No 11, Nov 89 pp 28-30

[Article by F. Ya. Boroday, engineer]

[Abstract] The strength characteristics of quartz ceramic are evaluated on the basis of experimental data and their statistical analysis. Specimens of this ceramic were produced by casting hydrous dross into gypsum molds and subsequent firing in silite furnaces 1245-1265°C for 2 h. The dross had a density of 1870-1900 kg/m^3, a viscosity index of 20-40 s, and a pH of 4.0-8.0, its grains including 20-30% of the up to 5 gmm fraction and 2-8% of the 63-500 μm fraction. The ceramic produced from this dross contained 18% of the 63-500 μm grain size fraction. Specimens of this ceramic were tested for flexural strength at room temperature (20°C) and at high temperatures up to 1100°C, also for impact strength. The average strength was found to increase with increasing porosity as well as with rising temperature, but the high-temperature strength values were widely scattered owing to variation of technological factors. Specimens with 11% porosity withstood not only 25 "heating to 1250°C within 15 min and cooling in water" cycles but also 16 "heating to 1350°C within 15 min and cooling in air for 15 min" cycles, while specimens with up to 2% porosity fractured during seventh and second cycles respectively. This ceramic combines high heat resistance with low thermal conductivity and retains its structural strength at temperatures up to 2000°C, even though its thickness decreases as a result of melting and evaporation. A typical application for this material is in solar heating plants, its capacity to absorb up to 13,750 kW/m^2 without fracture having been demonstrated in a special test which involved mechanical loading of 100 mm long 10 mm square bars according to the four-point scheme in a high-speed tensile testing machine and simultaneous unilateral heating of these bars by a special heliostat with a focusing parabolic reflector. Figures 4; tables 3; references 2.

UDC 666.1.031.14

Use of Rare-Earth Tailings in Manufacture of High-Transparence Glass

907D0126A Moscow STEKLO I KERAMIKA in Russian No 10, Oct 89 pp 4-5

[Article by Z. P. Beregovaya, engineer, Ye. A Shevchenko, engineer, and A. S. Zolotareva, candidate of technical sciences, Scientific Research Institute of Automotive Glass]

[Abstract] A feasibility study was made concerning use of rare-earth carbonate tailings from the Kirgisian Mining and Metallurgical Combine as decolorizer in the manufacture of high-transparence glass, some of these tailings having a high CeO_2 content (65-70 wt.%) accompanied by up to 14 wt.% Nd_2O_3 + La_2O_3 + Pr_6O_{11} in addition to Na_2O and other metal oxides. As base material was selected glass containing 72.6 wt % SiO_2 + 13.6 wt.% Na_2O + 8.7 wt.% CaO + 8.6 wt.% MgO + 1.0 wt.% Al_2O_3 + up to 0.5 wt.% SO_3, undesirable iron content having been removed. To this material were added carbonates of rare-earth elements in amounts corresponding to 0.0125-0.075 wt. % CeO_2. Corundum crucibles in an electric silite furnace served as the glass foundry operating at temperatures up to 1500°C. The thus modified glass was tested for transparence to 1.1 nm wavelength light, transparence being measured in percentage of incident light transmitted by a 1 cm thick layer of glass. The results indicate that addition of 0.05 wt.% CeO_2 in rare-earth carbonate tailings with a 79.3 wt.% total rare-earth content (65 wt.% or higher CeO_2 content) can yield glass with a transparence index of 90%/cm. Tables 3; references 1.

UDC 666.22

Mechanical Strength of Optical Fiber With Coating of Epoxy Acrylate Coating Hardened By Ultraviolet Radiation

907D0126B Moscow STEKLO I KERAMIKA in Russian No 10, Oct 89 pp 7-10

[Article by V. F. Chuprakov, candidate of physical and mathematical sciences, S. V. Koryshev, candidate of physical and mathematical sciences, N. M. Kononova, engineer, and P. B. Baskov, engineer]

[Abstract] Experimental data on the mechanical strength of optical graded index 125/50 "quartz core inside quartz sheath" fibers with a single layer coating of epoxy acrylate which has been hardened by ultraviolet treatment are fit into the Weibull distribution for a fiber reliability analysis, this distribution being compatible with the weak-link model of spliced fibers and its parameters being readily correlated with environmental factors. On the basis of Weibull diagrams have been calculated the life expectancy of such fibers under constant static or variable dynamic tensile stresses and their proneness to hydrolytic stress corrosion under a dynamic load, also their resistance to simultaneous action of neutral water (pH = 7) at room temperature and static tension. The results indicate that, as the rate of mechanical deformation under tension is increased from 5 mm/min to 500 mm/min, the breaking stress (statistical median stress level corresponding to 50% probability of fiber rupture) increases linearly to a 15% higher level. They also indicate that strength lost by such a fiber due to growth of cracks in a humid or moist atmosphere can be completely recovered by drying at 85°C for 1, but not by drying it at 40°C for 1 h. The effective fiber activation

energy calculated according to an equation of the Arrhenius kind establishes a linear relation between the logarithm of the time till rupture under a static load and the reciprocal of the absolute temperature, the time till rupture at any temperature becoming shorter under a heavier load. Figures 5; references 6.

UDC 666.293

Effectiveness of Composite Casting For Enameling

907D0126D Moscow STEKLO I KERAMIKA in Russian No 10, Oct 89 pp 14-15

[Article by F. D. Obolentsev, doctor of technical sciences, Ye. I. Litvinova, candidate of technical sciences, and O. Ya. Savchenko, candidate of technical sciences, All-Union Institute of Design and Technology for the Casting Industry, and Scientific Research Institute of Special Casting]

[Abstract] Composite casting of iron with steel sheaths reinforcing the surface of castings is considered for prevention of cracks, blisters, and other defects in the subsequently deposited enamel coating. The procedure involves stamping sheaths from sheet of grade 08 or St3 steel with a surface profile duplicating the profile of the surface to be enameled, insertion of these sheaths slipped over ceramic rods or drags into the mold, pouring molten iron into the mold, and removal of the casting from the mold. The final opera-tion, compressed-air blast, prepares the surface for enameling. The major advantage of this method is avoidance of intricate surface preparation for enameling. However, it requires a perfect bonding of steel to iron over the entire contact surface and formation of a mechanically strong layer of oxide (magnetite) on the steel surface to be enameled. The sheet steel of which the sheaths are made must be rustfree and otherwise clean. The cast iron should be ferritic-pearlitic throughout, in which case mottled white and gray formations do not degrade the enamel coating. The typically 16-18 μm thick magnetite layer on the steel surface together with a typically 6-8 μm thick interlayer separating it from the prime layer of enamel ensure adequate enamel- to-steel bonding. Figures 2; references 6.

UDC 666.76.032.654

Compound Pulsed-Static Pressing of Industrial-Grade Ceramics

907D0126E Moscow STEKLO I KERAMIKA in Russian No 10, Oct 89 pp 15-17

[Article by I. I. Molochkov, engineer, M. R. Leruma, candidate of technical sciences, V. A. Mironov, doctor of technical sciences, and U. Ya. Sedmalis, doctor of technical sciences, Riga Polytechnic Institute]

[Abstract] A comparative study of two methods of pressing industrial grade was made, plain cold static pressing into rigid molds and compound pulsed static pressing. Plain static pressing is a simple low-cost high-productivity process, not quite suitable for high-density ceramic and high precision requirements. It therefore was compounded with magnetic pulsing, better controllable than explosive pulsing and simpler than electrohydraulic pulsing, to lower the lateral pressure as well as intergranular and external friction. Two batches of ceramic material were tested, both classifiable as fine-grain ceramic on alumina binder, a batch of specially formulated basic reference material containing 34.50 wt.% SiO_2 + 32.28 wt.% Al_2O_3 + 12.08 wt.% ZrO_2 + 0.70 wt.% TiO_2 + 0.69 wt.% CaO + 6.0 wt.% MgO + 1.77 wt.% (Na_2O + K_2O) + 1.50 wt.% Fe_2O_3 + 2.03 wt.% Cr_2O_3 + 3.0 wt.% Y_2O_3 + 5.48 wt.% loss in firing and an experimental batch of nearly the same composition except with a different alumina content. The pressure for static pressing only was selected empirically to ensure a nearly critical density of the compacts, 110 MPa for the reference batch and 135 MPa for the experimental one. Compound pressing was done in two stages, static pressing under 20 MPa and 25 MPa respectively followed by pulses of 8.5 kJ and 10 kJ respectively. The compound process produced ceramics of 8% higher density and with 20-25% lower porosity and water absorption. The results of subsequent sintering with the temperature varied over the 1100-1250°C range for the reference batch and over the 1150-1300°C range for the experimental one indicated that the optimum temperatures were 1175°C and 1250°C respectively, no matter by which method they had been pressed. However, compound pressing contributed to softer sintering kinetics at or about the optimum temperature, with not only less but also more uniform shrinkage. Figures 3; tables 2; references 3.

UDC 666.5

Use of Laser Radiation For Flashing Porcelain Surfaces

907D0126F Moscow STEKLO I KERAMIKA inRussian No 10, Oct 89 pp 18-19

[Article by I. V. Aleksandrov, engineer, V. M. Strakhov, candidate of technical sciences, and Yu. P. Udalov, doctor of chemical sciences, All-Union Porcelain Scientific Research Institute]

[Abstract] Laser radiation was experimentally used for flashing the edges of hollow porcelains products for the purpose of obtaining a glazed-like surface, the advantages of this method including not only high concentration of energy over extremely small areas and very small losses of energy over long paths without use of special channeling devices but also the possibility of soft high-speed high-precision control of the power level along with stabilization in space and time. Considering that the efficiency of solid-state lasers such as a YAG : Nd^{3+} operating at the 1.06 μm wavelength is very low within

not more than 5%, an industrial continuous-wave CO_2-laser operating at the 10.6 μm wavelength and delivering decawatts of power at an efficiency of 10-20% was selected for this purpose. Silicates not being transparent to long-wave radiation beyond the 4.5 μm edge, most of the incident radiation will be absorbed by the porcelain and 10-15% will be reflected by its surface. For the experiment was used a "Khebr-1A" laser with transverse excitation in a three-pass optical cavity, its power being variable over the 50-1,000 W range. The laser beam could scan the stage with numeric program control at speeds up to 8000 mm/min. The optimum laser power and scanning rate were found to be 150 W and 2000 mm/min respectively, just so as to ensure sufficient flashing (which requires higher power and slower scanning) but avoid cracking (which requires lower power and faster scanning). The experimental data validate the engineering rule that the temperature of the porcelain be slightly above the melting of glass transition point, the latter being proportional to the incident laser power and inversely proportional to the square root of the scanning speed for a given material and a given thickness. The benefits of this flashing technique have been confirmed by microstructural examination of mullite-quartz porcelain after such a treatment. Figures 2; references 2.

UDC 666.3:621.791.053

Use of Ceramic Material for Formation of Welding Seam

907D0126G Moscow STEKLO I KERAMIKA in Russian No 10, Oct 89 pp 19-20

[Article by G. Z. Komskiy, candidate of technical sciences, P. V. Kolotnyy, candidate of technica' sciences, V. D. Boguslavskiy, engineer, and V. N. Kovalchuk, engineer, Ukrainian Scientific Research Institute of Porcelain Industry]

[Abstract] A special ceramic material has been developed for formation of welding seams and rings, in accordance with specifications set stipulated by the Institute of Electric Welding. The ring must withstand an electric arc flashover and a momentary contact with molten metal without itself melting more than to a 0.4 mm depth while retaining its nominal dimensions within +/-0.2 mm tight tolerances. The material is a mixture of mullite, cordieritic fireclay, Prosyanaya kaolin, Drushkovka clay, and alumina, its chemical composition being 50.75 wt.% SiO_2 + 34.3 wt.% Al_2O_2 + 3.62 wt% MgO + 11.2 wt.% CaO + 0.81 wt.% K_2O + 0.56 wt.% TiO_2 + 0.13 wt.% Na_2O + 6.46 wt.% loss in firing. The material is produced by wet grinding of its constituents and semidry pressing of the powder after it has been desiccated to a 7-9% residual moisture content. Ring specimens of this material were tested not only for technological characteristics including apparent density, porosity, water absorption, but also for mechanical properties including flexural strength and modulus of elasticity after calcination at maximum temperatures ranging from 1150°C to 1400°C. Sintering was found to be most intense at temperatures within 1150-1200 and 1300-1400°C, the strong temperature dependence of the sherd crystallization pattern within the 1300-1400°C range indicating a different sintering mode characterized by intense formation of a liquid phase. Dimensional stability of the ceramic rings was confirmed by the almost linear dependence of the firing shrinkage on the firing temperature, hardly any fluctuations occurring and hardly any blow holes forming during semidry compaction. The ceramic rings were also tested for resistance to thermal shock, the coefficient of linear thermal expansion of this material found to be within (2.7-3.5) x 10^{-6}/° after calcination at 1200-1400°C. Microstructural examination of ceramic product revealed mullite, quartz, cordiertite, corundum, and glass. Figures 2; references 1.

UDC 666.762.2.017:539.3

Mechanical Properties of Quartz Ceramic at Operating Temperature

907D0126H Moscow STEKLO I KERAMIKA in Russian No 10, Oct 89 pp 21-22

[Article by V. G. Panteleyev, candidate of technical sciences, N. V. Klyucheva, engineer, A. V. Struy, engineer, and K. S. Ramm, candidate of technical sciences, All-Union Porcelain Scientific Research Institute and State Institute of Optics imeni S. I. Vavilov]

[Abstract] Aging of structural and refractory quartz ceramic in service is examined on the basis of available experimental data, this material being produced by sintering fused or synthetic silica and subsequent heat treatment at temperatures up to 1300°C for special applications which require temperature cycling over the 1000-1200°C range or one-shot heating up to 1600°C. Considering that above 1200°C quartz glass-ceramic undergoes crystallization into cristobalite, which is indicated by the only peak on dilatometric curves, and that a faster temperature rise shift the maximum sintering rate to higher temperatures, 100 mm long 20 mm square bar specimens of this material fired at 1200°C were tested mechanically by the three-point bending method for high-temperature strength, modulus of elasticity, and creep at temperature covering the 20-1400C range. Both the strength and the modulus of elasticity were found to increase substantially after longer soaking at 1400°C, an indication of the beneficial role of cristobalite. The creep rate, meanwhile, was found to decrease substantially during the first 5 h at 1400°C but not any more thereafter. Examination under a scanning electron microscope and X-ray phase analysis after fracture revealed a nonuniform precipitation of the stabilizing phase with retention, in some specimens, of a noncrystallized core contributing to a more ductile fracture underneath an interlayer of microcracked granular cristobalite and a cellular cristobalite crust on top. The best specimens had

a flexural strength of 35 MPa and a modulus of elasticity approaching 53 GPa, their creep rate not exceeding 20 μm/h under a pressure load of 1.7 MPa. Figures 4; references 4.

UDC 666.291

Microstructure of Black Pigments on Basalt Base

907D0126I Moscow STEKLO I KERAMIKA in Russian No 10, Oct 89 pp 23-24

[Article by A.I. Shushanashvili, candidate of technical sciences, N.G. Rukhadze, engineer, M.N. Gogidze, engineer, L.K. Alaverdova, engineer, and L.K. Tedeishvili, engineer, Georgian Scientific Research Institute of Construction Materials and Tbilisi State Institute of Chemical Raw Mining Materials]

[Abstract] Inasmuch as basalt from the Marneuli deposit promises to be a good source of black and other dark high-temperature pigments, because it contains the four oxides MgO (15.00 wt.%) Fe_2O_3 (11.02 wt.%), TiO_2 (0.62 wt.%), MnO (0.52 wt.%), the optimum compositions of such pigments have been experimentally determined which will ensure required characteristics with a minimum oxide content. Pigments containing least Co_2O_3 were found to be most suitable for 800-1300°C operating temperatures. Two of these pigments, PKChK-1 containing 60 wt.% basalt + 20 wt.% Fe_2O_3 + 10 wt.% Co_2O_3 + 10 wt% Cr_2O_3 and PKSK-1 containing 40 wt.% basalt + 15 wt.% Fe_2O_3 + 30 wt.% $CoSO_4$ + 15 wt.% Cr_2O_3, were produced by conventional firing at 1200-1300°C. They were added to the VS-10 boronless industrial glazing compound which had been fired at various temperatures and the latter, with 10 wt.% of pigment, then deposited on various internal lining surfaces for subsequent firing at various temperatures from 800°C to 1300°C. Petrographical analysis revealed numerous never melted plagioclase crystals (20-25 wt.%) and pyroxene spherulites in the PKChK-1 pigment, much fewer of them (8-10 wt.%) in the PKSK-1 pigment. It also revealed a partial dissolution of these pigments in the glazing compound at 1300°C with attendant precipitation of spinels, which makes the subsequent pyroceramic crystallization of the compound proceed uniformly over its volume and thus contributes to high quality of black glaze. Figures 2; references 2.

UDC 661.968'546.23:541.138.3

Electrochemical Synthesis of Selenium Hydride

907D0144A Moscow VYSOKOCHISTYYE VESHCHESTVA in Russian No 2, Mar-Apr 90 pp 154-157

[Article by O.A. Glushachenko, L.F. Kozin, F.D. Manilevich, and L.S. Novikova, General and Inorganic Chemistry Institute, Ukrainian SSR Academy of Sciences, Kiev]

[Abstract] Selenium hydride for production of high-purity selenium was synthesized according to the reaction $Se + 2H^+ + 2e = H_2Se$ by electrochemical dissolution of a selenium-graphite cathode in sulfuric acid in a cell in which the cathode and anode compartments were separated by a porous glass diaphragm. The cathode compartment was flushed with argon in order to expel air and remove the product gases (selenium hydride and hydrogen). A platinum plate was used as anode. Sulfuric acid concentrations between 0.1 and 7 M, current densities between 10 and 130 mA/cm^2, and temperatures between 10 and 95°C were studied as process parameters. The current efficiency was found to have a maximum at 0.5 M sulfuric acid concentration, to increase steadily with temperature, and to have a maximum at 30 mA/cm^2. The maximum current efficiency (65 percent) was found at 0.5 M H_2SO_4, 30 mA/cm^2, and 95°C. It is suggested that current efficiency of nearly 100 percent can be obtained by raising the temperature to 140°C. Figures 3; references 16: 13 Russian, 3 Western.

UDC 546.289

Determination of Oxygen in High-Purity Germanium by Lithium Precipitation

907D0144B Moscow VYSOKOCHISTYYE VESHCHESTVA in Russian No 2, Mar-Apr 90 pp 217-219

[Article by G. G. Devyatykh, Yu. A. Nechuneyev, M. Yu. Pyatov, and I. V. Kiselev, Institute of Chemistry of High-Purity Materials, USSR Academy of Sciences]

[Abstract] P-type germanium specimens in which the main electrically active impurities were aluminum, copper, and impurity complexes associated with vacancies were polished, cleaned, etched with a 3 : 1 mixture of nitric and hydrofluoric acids, and alloyed with lithium by diffusion in argon atmosphere at 450°C. This was followed by determination of current-carrier concentration by the method reported by Van der Pauw and calculation of oxygen content from this concentration. It was found that oxygen concentration in high-purity p-type germanium is about 10^{14} atoms per cm^3. Figures 2, references 8: 2 Russian, 6 Western.

UDC 621.315.592:539.26

Analysis of Structure Perfection of $Pb_{1-x}Sn_xSe$ Single Crystals Grown From Vapor Phase

907D144C Moscow VYSOKOCHISTYYE VESHCHESTVA No 2, Mar-Apr 90 pp 237-239

[Article by N. I. Dolotov, V. A. Moshnikov, and V. V. Tomayev, Severo-Osetinsk State University imeni K.L. Khetagurov, Orzhonikidze]

[Abstract] Single crystals of a solid solution corresponding to $Pb_{0.93}Sn_{0.07}Se$ were grown from vapor phase under conditions close to quasi-congruent sublimation. They exhibited n-type conductivity, charge carrier density between 10^{17} and 5 x 10^{17}, and Hall mobility between 14,000 and 20,000 cm^2/V/s at 77°K. X-ray diffraction methods were used to evaluate the perfection of their structure before and after electrochemical etching in Norr's etchant (45 ml of 20 percent KOH, 35 ml of glycerin, and 20 ml of ethanol) in an apparatus that permitted microscope observation of the surface being etched. Natural crystal faces obtained by growth from the vapor phase showed smaller numbers of defects than cleavage faces. Electrochemical etching of cleavage faces is capable of completely removing the layer damaged by cleavage, thus reducing the number of defects. Figure 1; table 1; references 6: 4 Russian, 2 Western.

UDC 539.2

Viscosity Change During Melting of Solids

907D0142A Kiev AKADEMIYA NAUK USSR METALLOFIZIKA Vol 12 No 2, Mar-Apr 90 pp 45-48

[Article by Ye. B. Yakovlev, Institute of Mechanics and Optics, Leningrad]

[Abstract] The sharp fall of viscosity of metals upon transition from the solid state to the liquid state during melting is explained by regarding the melting process as transition of a crystal from a state of unstable thermodynamic equilibrium with a low concentration of vacancies to a stable state with a large concentration of vacancies. Consideration of relaxation of elastic deformation of a crystal lattice by a mechanism in which the length of atom chains is limited by point defects (B-defects), rather than by a mechanism in which the atomic planes are limited by edge dislocations, and calculation of the diffusion and frequency of formation and annihilation of B-defects yield an equation according to which viscosity ε is approximately equal to $2^{-3/5}\tau\alpha^{-1} \exp[(11E + 5E_a + 3E_d - 3E_B)/kT]$ where τ is time of the order of the reciprocal of the Debye frequency, α is a proportionality coefficient, E is the energy of formation of a vacancy, E_a is the energy that an atom must have in order to jump to a vacancy, E_B is the energy that an atom next to a B-defect must have in order to break an atom chain, E_d is the energy that an atom abreast of a divacancy must have if a B-defect is to form from a

divacancy, k is Boltzmann's constant, and T is the absolute temperature. Figure 1; references 7 Russian.

UDC 539.219.3

Description of Kinetics of Solid-Phase Diffusional-Amorphization Reactions

907D0142B Kiev AKADEMIYA NAUK USSR METALLOFIZIKA Vol 12 No 2, Mar-Apr 90 pp 48-52

[Article by A. M. Gusak and A. V. Nazarov, Pedagogical Institute, Cherkassy; Physical-Metallurgy and Metal-Physics Institute, TsNIIChM, Moscow]

[Abstract] Previously developed theory of phase formation and growth in the diffusion zone during mutual diffusion in the solid state that involves competition between phases at the nucleation stage was used to derive the conditions under which nuclei of an intermetallic phase sandwiched between an amorphous phase and a component of a crystalline alloy can not grow owing to the competition from the rapidly growing amorphous phase. These conditions involve the sizes of the nuclei, the concentration ranges of existence of the phases, and the diffusional permeabilities of the phases. It is proposed that amorphous-phase nuclei can form owing to "amorphous-like" types of grain boundaries or by irradiation. Figure 1; references 11: 5 Russian, 6 Western.

UDC 620.186:621.762:669.14

Structure of Rapidly Quenched Steel R18 at the Secondary-Hardening Stage

907D0142C Kiev AKADEMIYA NAUK USSR. METALLOFIZIKA in Russian Vol 12 No 2, Mar-Apr 90 pp 57-61

[Article by V. Ye. Vaganov, L. K. Mikhaylova, V. I. Kiriyenko, N. G. Shapoloshnikov, and L.A. Kudryavtseva, TsNIIChM (Central Ferrous-Metallurgy Scientific-Research Institute), Moscow]

[Abstract] Thin foils of high-speed tool steel R18 were prepared by levitation melting and quenching from the molten state and studied by transmission electron microscopy, field-emission microscopy, X-ray diffraction, and microhardness testing before and after tempering for 1 h at 200 to 700°C. Maximum hardness (10.7 ГPa) of rapidly quenched steel on the contact surface was obtained by tempering at 625°C, whereas the same steel quenched from the austenite temperature (1280°C) had a maximum hardness of 8ГPa after tempering at 600°C. The hardness of the free surface in as quenched condition was 6.5 ГPa, increasing to 7.5 ГPa after triple tempering at 650°C and to 9.5 ГPa after tempering at 600 to 650°C. The as-quenched steel had a predominantly austenitic structure on the contact surface and δ-ferritic structure on the free surface and in the interior. The phases that form during tempering at various temperatures are described. The high hardness of rapidly quenched steel R18 is shown to be due to the formation of rake-shaped martensite in austenite and decomposition of δ-ferrite with precipitation of fine Me_2 carbide. Figures 4; references 9: 5 Russian, 4 Western.

UDC 669.017.3:359.382

Effect of Low-Temperature Strain on the Phase Composition of the Ti-45 wt.% Nb Alloy

907D0142D Kiev AKADEMIYA NAUK USSR METALLOFIZIKA in Russian Vol 12 No 2, Mar-Apr 90 pp 78-83

[Article by V. A. Lototskaya, V. Ya. Ilichev, A. I. Prokhvatilov, and A. P. Isakina, FTINT (Physico-Technical Low-Temperature Institute, USSR Academy of Sciences, Kharkov)]

[Abstract] X-ray diffraction studies of phase composition at 5 to 293 K of as-drawn and of drawn, annealed (at 800°C), and water-quenched specimens after tensile straining from 0.1 to 2.5 percent at 20, 77, 140, 200, and 293 K are reported. The strain-stress tests were conducted with increasing and decreasing loads. Those conducted at 140 K or below reveal pseudoelasticity in quenched specimens, which indicates the formation of α"-martensite. Before being strained in tension, both as-drawn and quenched specimens show only a BCC β-solid solution at all temperatures between 5 and 293 K. The quenched specimens strained by up to two percent at 293 K show only the β-phase, but α"-martensite appears in them upon cooling to 140 K. The as-drawn specimens strained at room temperature retain their singe-phase structure down to 5 K. Both quenched and as-drawn specimens strained at 20, 77, and 140 K show both β and α phases at all temperatures between ɔ and 293 K. A strain of 20 to 25 percent at 296 K produces an ω-phase in addition to the α"-phase, but the ω-phase disappears at room temperature. Figures 2; table 1; references 10: 5 Russian, 5 Western.

UDC 539.23

Iteration Method in Kinetics of Condensation of Thin Films

907D0142E Kiev AKADEMIYA NAUK USSR. METALLOFIZIKA in Russian Vol 12 No 2, Mar-Apr 90 pp 104-109

[Article by A. V. Osipov, Leningrad Branch, Machinebuilding Institute, of the USSR Academy of Sciences]

[Abstract] An analytical method of solution of kinetic equations of condensation of thin films from the vapor phase based on a capillary model of nucleation is presented. The method employs a concept of ideal supersaturation that would exist if the number of adsorbed atoms in the system were equal to the number of particles condensed in the vapor and in the solid phase. The variation of ideal supersaturation is derived for the cases

of 1) condensation when supersaturation arises instantaneously and subsequently the atoms do not condense on the substrate, 2) condensation in the presence of a constant external source of particles, and 3) condensation when the life of adsorbed atoms is so short that the rise of supersaturation is limited by revaporization. References 8: 5 Russian, 3 Western.

UDC 621.762

Volume Changes in Liquid-Phase Sintering of Aluminum-Magnesium Powder Compacts

907D0143A Kiev POROSHKOVAYA METALLURGIYA in Russian No 3, Mar 90 pp 20-25

[Article by N. S. Timofeyev and A. P. Savitskiy, Institute of Physics of Strength and Materials Science, Siberian Department of the USSR Academy of Sciences and Tomsk Polytechnic Institute]

[Abstract] Volume changes of Al-Mg powder compacts containing 3.3 to 32.2 percent of magnesium powder were studied by sintering in a dilatometer at 460 to 610°C. It was found that initially heating to the sintering temperature is accompanied by thermal expansion of the specimens regardless of their magnesium content. Subsequent heating results in further expansion if the magnesium concentration puts the alloys within the solid-solution range and in shrinkage when the magnesium concentration is sufficiently high to put the alloys in the solid-liquid range, but the shrinkage never offsets the preceding expansion. Expansion is attributed to the diffusion of magnesium from the liquid phase to the solid phase, whereas shrinkage results from the dissolution of aluminum in the melt. Figures 4; tables 2; references 10 Russian.

UDC 621.763

Features of Formation of Interparticle Contacts in Sintering of Porous Molybdenum-Copper Composites

907D0143B Kiev POROSHKOVAYA METALLURGIYA in Russian No 3, Mar 90 pp 25-30

[Article by A. G. Kostornov and V. P. Semenets, Institute for Materials Science Problems, Ukrainian SSR Academy of Sciences]

[Abstract] Molybdenum-copper compacts containing 10 to 50 percent of copper powder were sintered at 1200°C (in the presence of liquid phase) and at 1000°C (solid-phase sintering) with addition of urea to produce initial porosity between 30 and 80 percent. Electrical resistivity was used as a measure of the quality of contacts between the molybdenum particles. It was found that contacts between the molybdenum particles is produced chiefly by copper bridges. Liquid-phase sintering produces better contacts than solid-phase sintering. For best control of the properties of porous composites that are sensitive to contact phenomena the copper content should be at least 30 percent. Figures 4; table 1; references 6 Russian.

UDC 621.762

Effect of Powder Properties and Compaction and Sintering Conditions on the Structure of Porous Niobium. 1. Effect of Powder Properties and Compaction Conditions on the Formation of Porous Structure of Niobium Material

907D0143C Kiev POROSHKOVAYA METALLURGIYA in Russian No 3, Mar 90 pp 30-33

[Article by Yu. V. Levinskiy, A. B. Zaytsev, Ya. M. Polyakov, and Yu. B. Patrikeyev, Moscow Institute of Fine Chemical Technology]

[Abstract] Niobium powder compacts were pressed from niobium powders prepared by reduction of niobium pentachloride with hydrogen (spherical particles with mean sizes of one and two microns, which were agglomerated to five and 17 microns, respectively, by heating in argon for one hour at 800 and 900°C to increase their bulk density and flow properties) as well as by aluminothermic reduction of niobium oxide, followed by vacuum-arc and electron-beam melting, hydrogenation of the ingots, grinding of the hydrogenation product, and dehydrogenation, which resulted in angular fragments with a mean size of eight to 10 microns. The formability of powders prepared from niobium pentoxide is much better than that of the powder prepared by aluminothermic reduction, but porosity-versus-compaction force curves show that their compactability is poorer. The specific pore surface area of the compacts was found to decrease as the powder particle size increases. A method of calculation of friction coefficient between the steel die and the compacts from the compaction forces and die geometry is reported. Figures 5; tables 2; references 5 Russian.

UDC 621.762:539.214

Structure and Properties of Chromium Powder Compacts Sintered by Electrical-Contact Heating

907D0143D Kiev POROSHKOVAYA METALLURGIYA in Russian No 3, Mar 90 pp 20-25

[Article by L. O. Andrushchik, O. N. Balakshina, S. P. Oshkaderov, and Ye. N. Severyanina, Metals Physics Institute, Ukrainian SSR Academy of Sciences and Institute for Materials Science Problems, Ukrainian SSR Academy of Sciences]

[Abstract] Chromium compacts were sintered in dry hydrogen at 1573, 1673, and 1773 K for up to 1800 s by passing industrial-frequency current through them, and their porosity, microstresses, and dislocation density were determined in order to find the optimum sintering temperature and time. Porosity at first increased for

about 60 s at all sintering temperatures and then decreased to a plateau upon further heating. The lowest porosity at the plateau was observed in specimens sintered at 1773 K, but that in specimens sintered at 1673 K was only slightly higher. The smallest average pore size was observed in specimens sintered for 300 s at 1673 K. X-ray diffraction studies showed that the specimens sintered for 300 s at 1673 K also exhibited a low level of microstresses and a low dislocation density. Therefore sintering for 300 s at 1673 K should produce the best mechanical properties. Figures 4; references 9 Russian.

UDC 546.823:271:17:1

Properties of Titanium Nitride-Diboride Composites Prepared From Very Fine Powders

907D0143E Kiev POROSHKOVAYA METALLURGIYA in Russian No 3, Mar 90 pp 47-49

[Article by Ya. A. Krastinsh, I. V. Zalite, and T. N. Miller, Inorganic Chemistry Institute, Latvian SSR Academy of Sciences]

[Abstract] Powder composites containing 30 percent of titanium diboride and 70 percent of titanium nitride were prepared from powders with a specific surface area of 38 m^2/g by sintering at 1600, 1800, and 2000°C after cold compaction in dies, hydrostatic compaction, and single and multiple explosive compaction to densities between 2.52 and 3.02 g/cm^3, as well as by high-temperature compaction at 1300 and 1400°C and 20, 176.5, and 5000 Mpa. Density, Vicker's hardness, and bending strength of the compacts after sintering or hot compaction increase and open and total porosity decreases with increasing sintering or compaction temperature and compaction pressure. High-temperature compaction produces the lowest porosity and the highest density, hardness, and strength. The grain size of hot-compacted composites decreases with increasing compaction pressure. Figure 1; table 1; references 6: 5 Russian, 1 Western.

UDC 621.793.7

Structure and Properties of Gas-Flame Coatings From Iron-Base Self-Fluxing Powder

907D0143F Kiev POROSHKOVAYA METALLURGIYA in Russian No 3, Mar 90 pp 50-53

[Article by I. N. Gorbatov, A.G. Zherdin, Yu. K. Pokrovskiy, O. D. Timoshenko, S. Yu. Koshkina, I. V. Fedorenko, and T. Ye. Gerus, Institute for Materials Science Problems, Ukrainian SSR Academy of Sciences]

[Abstract] Chromium-, carbon-, silicon-, and boron-containing iron powder was used to apply 2 to 3-mm thick coatings on carbon steel with an oxygen-propane-butane burner. It was established by optical and scanning electron microscopy and microhardness measurement that the coating consisted of hard $(Cr, Fe)_{23}(C,B)_6$ borocarbides uniformly dispersed within a soft, fine-grained eutectic consisting of a solid solution of carbon, silicon, and chromium in iron. Wear tests show that the coatings can serve as an inexpensive replacement for nickel-alloy coatings for service under the conditions of sliding friction at a pressure up to 2 Mpa and a sliding velocity of 1 m/s. Figures 3; table 1; references 6 Russian.

586.621.1.016.7:661.685

Reactions of Mixtures of Tungsten and Silicon Oxides With Carbon

907D0143G Kiev POROSHKOVAYA METALLURGIYA in Russian No 3, Mar 90 pp 72-75

[Article by V. S. Sinelnikova, S. P. Gordiyenko, V. A. Melnikova, O. I. Popova, and O. T. Khorpyakov, Institute For Materials-Science Problems, Ukrainian SSR Academy of Sciences]

[Abstract] Mixtures of fine WO_3, SiO_2, and C powders were heated at 1173 to 1673 K in vacuum and in a stream of argon in order to reduce the oxides to WS_2. The reaction gases were analyzed by mass spectrometry. The solid products were studied by chemical, X-ray diffraction, and electron microprobe methods. Vacuum reduction of a stoichiometric mixture at 1173 produced only W_2 and WC and some unreacted SiO_2. WSi_2, W_5Si_3, and traces of WC form at higher temperatures. W_5Si_3 forms because the stoichiometry of production of WSi_2 is upset by reduction of SiO_2 to volatile SiO and reaction of SiO_2 with WC. A low-carbon single-phase product (WSi_2) forms in vacuum at 1473 K when the reaction mixture contains an 80 percent excess of SiO_2 and a 35 to 40 percent excess of carbon. Reaction in a stream of argon failed to produce pure WSi_2 because then the reduction requires higher temperatures, which favor the formation of tungsten carbides. Figures 2; tables 3; references 3: 2 Russian, 1 Western.

UDC 539.217.1(088.8)

Structure and Hydrodynamic and Strength Properties of Porous Materials Made From Corrosion-Resistant Steels

907D0143H Kiev POROSHKOVAYA METALLURGIYA in Russian No 3, Mar 90 pp 85-90

[Article by P. A. Vityaz, V. M. Kaptsevich, V. K. Sheleg, A. N. Sorokina, S. A. Bedenko, V. V. Savich, A. Ye. Galkin, and Z. A. Vasilevskaya, Belorussian Republic Powder Metallurgy Scientific and Production Association]

[Abstract] Strength, porosity, and permeability of sintered powder compacts for filter applications made from spherical and nonspherical steel particles, with and without addition of urea or copper powder, were studied. Spherical particles give more permeable compacts, but

the strength of these compacts is lower than that of compacts produced from nonspherical particles. Particle size is the main factor that determines the permeability of compacts made from spherical particles, whereas the compaction pressure determines the permeability and pore size of compacts made from nonspherical particles. Addition of urea to the powder mix increases the porosity and permeability of powder compacts but lowers their strength to possibly unacceptable levels. The strength loss can be reduced by addition of copper powder, particularly to spherical steel powder. Various combinations of permeability and strength can be obtained by mixing spherical and nonspherical powders in various proportions and employing various compaction pressures. Figures 3; tables 4; references 8 Russian.

UDC 621.762

Defects Arising in Industrial Production of Powder-Compact Articles

907D0143I Kiev POROSHKOVAYA METALLURGIYA in Russian No 3, Mar 90 pp 93-98

[Article by Yu. G. Dorofeyev, A. T. Mamedov, G. A. Dreyev, and V. V. Rumyantsev, Novocherkassk Polytechnic Institute, Bakkonditsioner Production Association, and Rostselmash Plant]

[Abstract] A review of authors' experiences with formation of loose, spongy structure in sintered powder compacts is presented. Oxygen and moisture in sintering atmosphere, hydrogen dissolved in the powder, suface oxidation of powder particles, and zinc stearate and graphite in the powder may cause the formation of loose, spongy stucture. Hard particles are more likely to form spongy structure. Some remedies are suggested. Figures 4; table 1; references 4 Russian.

UDC 548.0.53

Contact Melting in Crossed Electric and Magnetic Fields

907D0123A Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA METALLY in Russian No 1, Jan-Feb 90 pp 58-62

[Article by I. M. Temukuyev, M. L. Balde, and P. A. Siventsev, Nalchik]

[Abstract] Results are presented from experimental studies on the influence of crossed electric and magnetic fields on the process of contact melting in the systems Bi-Sn, Bi-Cd and Cd-Sn. Contact melting was performed in a homogeneous magnetic field in a liquid thermostat with the magnetic field perpendicular to the axis of the cylindrical specimens, which were in contact at their ends. A microscope was used to observe the movement of the interface between the crystal and the liquid. The rate of contact melting of the alloys was found to vary in a complex manner with time. At certain values of j and B, the contact melting rate increased by an order of magnitude or more. The crystal-liquid interface was found to curve in systems both with and without bismuth. The crossed electric and magnetic fields influenced the system through Lorentz forces acting on diffusing ions and exchange electromagnetic forces causing convective movement in the liquid layer. The influence of the crossed fields should be significant at temperatures near the utectic point, where the rate of contact melting and therefore of diffusion processes is very low. Figures 3; References 10 (Russian). COPYRIGHT: Izdatelstvo "Nauka", Tekhnicheskaya kibernetika", AN SSR., 1990

UDC 669.15'74-194:620.17

Influence of Aluminum Content on Properties of High Manganese Steel Type 110G13L

907D0123B Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA METALLY in Russian No 1, Jan-Feb 90 pp 73-75

[Article by M. I. Kurbatov, A. S. Nosenko, E. G. Zemka, and Ya. P. Protsenko, Zaporozhye]

[Abstract] A study is made of the influence of aluminum, titanium and vanadium as deoxidizers on the properties of 110G13L steel. The steel was made in a six-ton basic arc furnace, poured in fractions, with aluminum added to the 300-kilogram ladles. The chemical composition of the steel in mass percent was: C 1.14, Mn 12.16, Si 0.49, P 0.062, S 0.01. Mechanical properties and wear resistance were determined on cast specimens treated in the pouring ladle on a conveyor. The metal was poured at 1480-1520°C. The same specimens were used for studies of the structure, nonmetallic inclusions and content of gases in the metal. It was found that the content of oxygen, nitrogen and hydrogen varies little with aluminum concentration. Aluminum content also did not influence the size of austenite structure blocks. High-manganese steel without aluminum was found to have higher toughness, ductility, strength and wear resistance. COPYRIGHT: Izdatelstvo "Nauka", Tekhnicheskaya Kibernetika", AN SSR., 1990

UDC 669.245'782:669.017.3

Phase Composition and Thermal Stability of Cast Heat-Resistant Nickel Alloy With Silicon

907D0123C Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA METALLY in Russian No 1, Jan-Feb 90 pp 94-98

[Article by V. V. Sidorov, G. I. Morozova, N. V. Petrushin, Ye. A. Kuleshova, A. M. Kulebyakina, and L. I. Dmitriyeva, Moscow]

[Abstract] A study is made of the influence of silicon on the phase composition and durability of cast heat-resistant nickel alloy with graphite in the system Ni-Cr-Co-W-Al-Ti-Nb-Hf-C, containing 0.16 mass percent C, 0.05-0.37 mass percent Si. The alloy was made in a vacuum induction furnace, poured with and without an additive of 0.2 or 0.4 percent silicon into ceramic blocks to produce specimens with equiaxial structure. The phase composition of the alloys was studied by physical-chemical phase analysis and microscopic X-ray spectral analysis, the morphology of the carbide phases was studied with a microscope, and processes of crystallization and the temperature of phase conversions were studied by differential thermal analysis. It was found that increasing silicon content to 0.4 percent increased the fraction of nonequilibrium γ-γ' utectic and caused additional separation of Me_6C and MeC carbides. Silicon initiates carbide conversions during high-temperature isothermic holding and under creep conditions, increasing the rate of coagulation of the γ' phase, thus decreasing short-term ductility and long-term durability of the alloy. Figures 4; References 7: 5 Russian, 2 Western. COPYRIGHT: Izdatelstvo "Nauka", Tekhnicheskaya kibernetika", AN SSR., 1990

UDC 621.357.7

Formation of Iron-Nickel Coating Structure Depending on Electrocrystallization Conditions

907D0123D Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA METALLY in Russian No 1, Jan-Feb 90 pp 117-119

[Article by I. M. Kovenskiy and V. V. Povetkin, Tyumen]

[Abstract] Cast Fe-Ni alloys crystallizing with bcc lattice are solid solutions of nickel in iron, but the structural state of similar electrodeposited alloys may differ significantly. This article studies the structure and phase composition of cathode precipitates of Fe plus 12.7 at. % Ni obtained with cathode polarizations of 130, 280 and 380 mV. The copper substrate was melted to produce foils about 20 μm thick which were then used for structural studies by X-ray phase analysis and gamma-resonant spectroscopy. Increasing the polarization to 280 mV resulted in smaller grain and higher dislocation density. Further increases in cathode polarization to 380 mV yielded a fine-grain alloy with grain size about 50 nm, dislocation density 10^{12} cm^{-2} with nonequilibrium phase composition. Thus, increasing the cathode potential increases the concentration of structural imperfections, the heterogeneity of the solid solution and causes formation of phases not present on the equilibrium state diagram. Figures 2; References 7: 6 Russian, 1 Western. COPYRIGHT: Izdatelstvo "Nauka", Tekhnicheskaya kibernetika", AN SSR., 1990

UDC 539.89:546-114

Oxidation and Compaction of Diamond Powder Produced From Hydrocarbons

907D0117A Kiev SVERKHTVERDYYE MATERIALY in Russian No 1, Jan-Feb 90 pp 14-18

[Article by O. A. Voronov, A. A. Kaurov, and Ye. S. Chebotareva, Institute of High-Pressure Physics, USSR Academy of Sciences, Troitsk (Moscow Oblast)]

[Abstract] An experimental study of 30/20 diamond powder was made concerning its oxidation, this powder having been produced by comminution of "white ballas" which forms during decomposition of hydrocarbons under a pressure and at a temperature within the range of thermodynamic stability of diamond. Powder produced by crushing cylindrical "white ballas" specimens 4 mm in diameter and 3 mm high were segregated into size fractions for separate but equal chemical treatment by etching with perchloric acid, with hydrofluoric acid, and with aqua regia. A powder specimen weighing 50 mg was poured into an open corundum crucible, forming here a loose layer of uniform thickness and mixing with corundum powder. The container carrying this crucible and several thermocouples was covered with a quartz cup holding 100 cm^3. With slow but steady influx of air and the derivatograph operating in the dynamic mode, the container was heated first to 500°C at a rate of 10°C/min and after a 15 min holding period at that temperature, to 1000°C at a rate of 1.25°C/min. The thermal effect was positive throughout this treatment, the mass of natural diamond having dropped to one half at 720°C and the mass of "white ballas" having dropped to one half at 770°C. The oxidation activation energy was estimated from the derivatograms of loss of mass as a function of time at several constant temperatures within the 600-1000°C range. Analysis of the data on the basis of model describing describing the kinetics of one-particle and two-particle reactions with a canonical energy distribution of free particles and on the basis of the quantum-mechanical indeterminacy relation yields a general expression describing the loss of mass by combustion as an exponential function of the temperature and a linear function of time, the form of this relation being somewhat different for the special case of combustion in a hermetically closed space. Powder specimens were subsequently compacted into disks 4-20 mm in diameter having an thermal conductivity of 350-450 W/(m.°C) and an electrical resistivity higher than 10^{10} ohm.cm, compacts of such sizes now cut with a YAG:Nd laser from preforms produced under pressures as high as 30 MN having been found to be sufficiently oxidation-resistant for use in electronic devices. The authors thank Ye.N. Yakovlev for helpful discussions and comments, A.V. Rakhmanina and A.I. Fedorov for assistance. Figures 3; references 10.

UDC 536.2:666.233

Effect of Thermal Resistance of Contact on Thermal Conductivity of Binary Composite Materials With Diamond Component, Part 2

907D0117B Kiev SVERKHTVERDYYE MATERIALY in Russian No 1, Jan-Feb 90 pp 21-25

[Article by V. I. Nepsha, V. R. Grinberg, Yu. A. Klyuyev, N. A. Kolchemanov, and V. V. Zhuravlev, Scientific-Industrial Association 'VNIIALMAZ' (All-Union Diamond Scientific Research Institute), Moscow]

[Abstract] The effective thermal conductivity of binary composite materials with a diamond filler component and a binder component is calculated theoretically, assuming a uniform distribution but random orientation of generally nonisometric cylindrical grains. The calculation is based on the model of such a grain inside a circumscribing it cubical cell and is performed by first subdividing a grain into elements for either adiabatic or isothermal heat flow, then taking into account thermal resistance of the filler-binder interface as well as that of the grain elements and of the binder. The result is an analytical expression for the effective thermal conductivity λ equal to the product of thermal conductivity in the direction parallel to the chain of grain elements and some function which characterizes the anisotropy of heat conduction (function of the λ parallel /λ perpendicular ratio), this function being different for parallel adiabatic and transverse isothermal heat flow. As a special case is considered a precise mutual orientation of grains. Numerical estimates made for cylindrical grains with the length-to-diameter ratio ranging from 1.77 (needles) to 0.32 (disks) and including isometric cylinders within the middle of that range reveal a significant influence of the filler-binder interface on the effective thermal conductivity of such a composite material. Figures 3; tables 2; references 2.

UDC 661.65:661.65

New Abrasive Material Made of Kiborite

907D0117C Kiev SVERKHTVERDYYE MATERIALY in Russian No 1, Jan-Feb 90 pp 36-39

[Article by A. A. Shulzhenko, Yu. I. Nikitin, S. M. Uman, S. A. Bozhko, and N. P. Bezhenar, Institute of Superhard Materials, UkSSR Academy of Sciences, Kiev]

[Abstract] A new superhard abrasive material has been developed for grinding wheels, a dense modification of boron nitride consisting of polycrystalline kiborite and producible as powder of any grain size from 2000/1600 to 50/40. It is as hard as Hexanit-R but more wear-resistant under impact loads than Hexanite-R, Elbor-RM, and Amborite. Its abrasiveness index of this material is higher than that of AS2 and AS6 diamond powder, the difference increasing as powders of smaller grain sizes are compared. Figures 2; tables 3; references 11.

UDC 621.9.025.7

Improving Performance and Reliability of Ceramic Cutting Tool

907D0117D Kiev SVERKHTVERDYYE MATERIALY in Russian No 1, Jan-Feb 90 pp 48-53

[Article by Yu. G. Kabaldin and O. B. Kovalev, Komsomolskiy-na-Amure Polytechnic Institute, and A. A. Shepelev, Institute of Superhard Materials, UkSSR Academy of Sciences, Kiev]

[Abstract] An experimental study of ceramic cutting tools was made for the purpose of improving their performance an reliability. Tools made of oxide ceramic (ZrMo332 including Al_2O_3 and MgO grains, WO13 including MgO grains, WOCo60, WOCo63, WOCo71, CorTiNit), of oxide-carbide ceramic (oxide ceramic hardened by inclusion of TiC, WC, Mo_2, ZrO_2 grains), and of nitride ceramic (Silinit-R Si_3N_4 were tested for wear and fracture in cutting grade-45 carbon steel hardened to Rockwell C 40-45. Cutting was done at a speed of 90 m/min, with a feed rate of 0.46 mm/rev and a 1 mm cutting depth. The same steel as well as 40CrNi alloy steel hardened to Rockwell C 40-45 and several grades of special high-strength cast iron were cut at speeds of 150-300 mm/min with feed rates of 0.1-0.21 mm/rev and 0.2-0.5 mm cutting depths. The results of these tests and X-ray spectrum microanalysis indicate that the temperature of α-Fe $\rightarrow$ γ-Fe phase transformation begins and thermodynamic potentials favorable to oxidation of the various metallic elements and silicon in steel or in cast iron may be reached within the cutting zone. These conclusions combined with the results of structural analysis suggest that performance and reliability of oxide and nitride ceramics are most effectively improved by reduction of the porosity with complete elimination of oxygonal pores, by a higher degree of structural homogeneity with smaller grains, and by use of modifiers not adhering to iron. Brittle fracture of oxide-carbide ceramic can be prevented and stability of its cutting characteristics can be achieved with smaller matrix grains and by optimum selection of hardener grains, improving its performance and reliability then requiring appropriate diamond treatment and surface polish. Figures 3; tables 3; references 8.

UDC 621.822.5

Wear Resistance of Slide Bearings With Alumina Coating

907D0117E Kiev SVERKHTVERDYYE MATERIALY in Russian No 1, Jan-Feb 90 pp 61-63

[Article by A. V. Parkhomenko, I. M. Komskaya, K. A. Cherepanov, A. V. Chernyshov, A. V. Galkov, and A. A. Ivanenko, Institute of Superhard Materials, UkSSR Academy of Sciences, Kiev]

[Abstract] An experimental study of "sleeve bearing on a crankpin" friction pairs was made, for an evaluation of

their service life depending on the surface material and surface treatment, the bearing surface having been coated with alumina powder (grain size 30-40 μm, porosity 0.5-2.0%, mean pore diameter 0.09-0.15 μm, density 3.4-3.5 g/cm^3, hardness Rockwell C 70, strength of adhesion to substrate 68.5 MPa) by detonation spraying. Tests were performed in a friction machine with bare and coated "disks" of 50Mn2 alloy steel rubbing against babbit-BI "bushings" at a velocity of 3.2 m/s under a pressure of 8.7 MPa in an oil bath, the conditions simulating operation of the crankshaft of the Model 238 automobile engine (manufactured in Japan). The results indicate that "disks" coated with alumina powder had a seven times higher wear resistance than the bare ones, while the wear resistance of "bushings" rubbing against alumina coating was 33% lower than that of "bushings" rubbing against steel. The decrease of their wear resistance was most probably caused by the faceting and greater roughness of the alumina surface, as indicated by subsequent tests after that surface had been ground with a diamond wheel and then superfinished. On the basis of this study, deposition of alumina coatings by detonation spraying is recommended for reconstitution of main journals and crankpins, but must be followed by diamond grinding and subsequent superfinishing of the surface. Tables 1; references 2.

UDC 541.183:532.6

Dependence of Diamond Crystal Growth Pattern on Wettability of Diamond Crystal Facets By Metal Melts

907D0119A Kiev SVERKHTVERDYYE MATERIALY in Russian No 6, Nov-Dec 89 pp 3-6

[Article by Yu. V. Naydich, V. M. Perevertaylo, and O. B. Loginova, Institute of Problems in Materials Science, UkSSR Academy of Sciences, Kiev]

[Abstract] An experimental study of diamond crystal growth was made concerning dependence of the growth pattern on the wettability of diamond crystal facets by Ni-Mn-B melts. Single crystals from the Yakutsk Group VIII deposit with polished (111) and (100) facets were tested by the quiescent droplet method in an atmosphere of high-purity helium at a temperature of 1473 K and under a pressure of 30 kPa. Alloys of the Ni-Mn-B system with a constant Ni:Mn = 40:60 ratio and a variable 0-30 at.% B content were produced by argonarc smelting. Diamond crystals were heated pairwise almost touching in a furnace, carrying each time a droplet of the same molten alloy one on its (111) facet and one on its (100) facet. Addition of up to 10 at.% B was found to improve the wettability of diamond crystals, a (100) facet better than a (111) facet, more than 5 at.% B causing buildup of edge corners and more than 10 at.% causing their inversion. An explanation of the results is found in the relation between facet growth and surface tension according to the Gibbs-Curie-Wulff principle of minimum surface energy and the Dupré equation for a solid-liquid interface. Figures 1; references 19.

UDC 621.762.5

Material Containing Cubonit With Nickel Binder Produced By High-Speed Sintering Under Pressure

907D0119C Kiev SVERKHTVERDYYE MATERIALY in Russian No 6, Nov-Dec 89 pp 15-17

[Article by V. P. Pereyaslov, L. M. Bologova, M. N. Voloshin, V. P. Kolomiyets, and P. I. Bologov, Institute of Superhard Materials, UkSSR Academy of Sciences, Kiev]

[Abstract] Thin layers of a composite material consisting of cubonit KR 100/80 grains embedded in PNE-1 nickel powder were produced by high-speed sintering under pressure in molds of quench-hardened steel, their thickness being of the order of 1 mm. Examination by metallographical methods with aqua regia used for etching and also under an electron microscope has revealed that cubonit retains its original strength when sintered under optimum conditions, an apparent 3.8% loss of strength being well within the +/-10% error of measurements. The optimally sintered tool heads contain 0.32 mg cubonit per gram of nickel powder and thus much less galvanically coated ones. Figures 3; references 5.

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Effect of Thermal Resistance of Contact on Thermal Conductivity of Binary Composite Materials With Diamond Component, Part 1

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[Article by V. I. Nepsha, V. R. Grinberg, Yu. A. Klyuyev, N. A. Kolchemanov, and V. V. Zhuravlev, Scientific-Industrial Association 'VNIIALMAZ' (All-Union Diamond Scientific Research Institute), Moscow]

[Abstract] The effective thermal conductivity of a binary composite material consisting of a continuous binder phase (thermal conductivity γ_c) and a disperse filler phase (thermal conductivity γ_d) is calculated in accordance with the generalized conductivity theory using an elementary cell of the composite material: a rectangular parallelepiped of the binder (dimensions L_x, L_y, L_z) containing a small rectangular parallelepiped of the filler (dimensions l_x, l_y, l_z). Such a cell is cut into characteristic regions, either by planes perpendicular to the direction of heat flow and assumed to be isothermal or by planes parallel to the direction of heat flow and assumed to be adiabatic. Two different expressions are accordingly obtained for the γ_{eff}/γ_d ratio, the thermal resistance of the binder filler interface having been included in "equivalent circuit" calculations. In the adiabatic

approximation there is found to be a critical filler grain size which makes the effective thermal conductivity of the composite material equal to that of the filler component even when the latter is higher than that of the binder component. The effective thermal conductivity of the composite material is higher or lower than that of the filler component depending on whether the filler grain is respectively larger or smaller than that critical size. Numerical estimates for a composite material with various volume fractions of a diamond filler in a copper or nickel binder matrix are made on the basis of applicable theoretical relations aided by experimental data: γ_{Cu} = 400 W/(m.K) and γ_{Ni} = 100 W/(m.K) at 300 K, γ_d = 2000 W/(m.K) max (natural diamonds) and γ_d = 1000 W/m.K (synthetic diamond single crystal). When the filler-binder interface is ideal with zero thermal resistance, then the composite material is thermally isotropic with filler grains of any shape and its effective thermal conductivity depends only on the filler volume fraction and on the ratio of filler grain to binder cell dimensions, otherwise it is anisotropic and its effective thermal conductivity will also depend on the shape of the filler grain. This is demonstrated on filler grains having square cross-sections $l_y = l_z$ and a length $l_x = l_y = ml_z$ so that ratio m becomes another variable on which the effective thermal conductivity of the composite material will depend. Figures 2; tables 1; references 13.

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Thermal Conductivity and Structural Characteristics of Cubic Polycrystalline Boron Nitride

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[Article by A. P. Podoba, T. T. Ositinskaya, A. V. Belyankina, and I. A. Petrusha, Institute of Superhard Materials, UkSSR Academy of Sciences, Kiev]

[Abstract] An experimental study of single-phase polycrystalline sphaleritic boron nitride produced from various source materials by sintering was made, for a comparative evaluation of its thermal conductivity and structural characteristics. Some specimens for this study had been produced from graphitic BN powder, the latter having been obtained by either the carbamide process or the carbothermal process. Other specimens had been produced from wurtzitic BN powder by dynamic synthesis, from dense pyrolytic graphite-like BN powder obtained by chemical deposition from the gaseous phase, and from sphaleritic 50/40 powder obtained by a special technology, also from kibor KT, from cubonit grades KR, KO and from elbor grades LKV, LO. Sintering was done in a toroidal high-pressure reactor, with temperature and pressure calibration against those at the center of the reaction zone. The degree of structural perfection of the polycrystalline specimens was found to depend on the source material. Their thermal conductivity was measured by the method of thermal flux constriction in the stationary mode, this method having been refined for superhard materials and the instruments having been modified for higher precision. The substructure of polycrystalline BN disk specimens was examined in a DRON-20 X-ray diffractometer with filtered radiation from a copper anode carrying a current of 5-10 mA at a voltage of 25-30 kV. The integral widths of both 331 and 200 lines serving as indicators of lattice microdistortions, narrower lines corresponding to higher thermal conductivity. Polycrystals produced from sphaleritic 50/40 BN powder by special technology and those produced from kibor KT powder were pure and colorless or slightly tinted with a high thermal conductivity of 280-380 W/(m.K) at 300 K. Polycrystals produced from pyrolytic graphite-like BN powder were the purest and their thermal conductivity varied over the 180-450 W/(m.K) range, rarely reaching 570 W/(m.K). Figures 2; tables 1; references 11.

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High-Pressure Sintering of Titanium Diboride

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[Article by A. M. Mazurenko, V. S. Urbanovich, and A. I. Olekhnovich, Institute of Solid-State and Semiconductor Physics, BSSR Academy of Sciences, Minsk]

[Abstract] Sintering of TiB_2 first under a pressure of 2.5 GPa and then under a pressure of 4 GPa at temperatures of 1300-2000°C was studied, the original powder from the Donetsk Chemical Reagents Manufacturing Plant having a specific surface of 0.086 m^2/g and consisting of grains not larger than 60 μm. The density of specimens after heat treatment was measured by hydrostatic weighing in CCl_4. Structural analysis was performed in a DRON-3 X-ray diffractometer with a CuK_α-radiation source and a graphite monochromator, the lattice parameters being determined on the basis of the three lines 112, 211, 203. The sintering and compaction data are evaluated in accordance with the Avrahami-Yerofeyev equation of the topochemical model $(\rho-\rho_0)/\rho_t = 1 - e(-ct^n)$ (ρ, ρ_0, and ρ_t) denoting the instantaneous density at any time, the initial density, and the theoretical density, c being the compaction rate constant at given temperature and pressure, t being the duration of the sintering process, and n being another constant) and in accordance with the Arrhenius equation $c = c_0e(-U_a/RT)$ where E_a is the sintering activation energy. X-ray diffraction data reveal that the 211 line and even more so the trailing lines become broader as the pressure is raised, while raising the temperature causes them to shift toward wider angles. When the sintering activation energy exceeds the dislocation movement activation energy, under higher pressure, diffusion becomes the governing process and plastic deformation occurs while dislocations multiply and vacancy defects build up in the metal (Ti) sublattice. Figures 3; tables 1; references 15.

UDC 621.9.025.7.004.17

Using Tungstenless Hard Alloy Tool For Machining Sprayed Coatings

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[Article by N. V. Spiridonov, G. Ya. Belyayev, and E. A. Kolchanov, Belorussian Polytechnic Institute, Minsk]

[Abstract] Rough machinability of sprayed coatings by a tungstenless hard alloy tool was studied in an experiment with coatings of self-fluxing powder-metal alloys PN-CrNi80Si3B3 and PN-CrNi80Si4B4 deposited by the gas-flame method on shafts made of 40Cr chromium steel. The thickness of these coatings varied over the 2.5-3.5 mm range and their hardness varied over the Rockwell C 45-55 range. They were turned on a lathe with cutting tools made of tungstenless hard alloys TiN-20 and CoNiTi-16, before and after the tool plates had been hardened by treatment with a continuous-wave laser beam. The feed rate was 0.21 mm/rev and the depth of feed was 0.25 mm. A crater wear of 0.35 mm and 0.40 mm respectively was regarded as blunting of the TiN-20 tool and the CoNiTi-16 tool. Cutting was also done with a Ti15Co6 tool (blunting upon a crater wear of 0.5 mm), for reference, this tool requiring the smallest cutting force. The largest cutting force was required with the CoNiTi-16 tool. The results of this study qualify both laser-hardened TiN-20 and CoNiTi-16 tools as adequate for machining sprayed coatings at a speed of 0.12-0.15 m/s, with a feed rate within the 0.20-0.25 mm/rev range and a 0.4 mm depth of feed. These tools will, under these conditions, remain stable for 17-20 min. Figures 2; tables 2; references 1.

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Deformability of TiN_x Powders Under High Pressure and Impact Loads

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[Article by A. Ye. Kravchik, V. S. Neshpor, and S. S. Ordanyan, Leningrad Institute of Technology imeni Lensovet and All-Union Scientific Research Institute of Abrasives and Grinding]

[Abstract] An experimental study of TiN_x powders with $x = 1.0, 0.8, 0.6$ was made concerning structural changes such as microdeformation of their crystal lattice under high pressure and under impact loads, such powders had been produced by dissolution of high-purity titanium in pure titanium nitride from the Donetsk Chemical Reagents Manufacturing Plant. Heat treatment of the TiN-N mixture in an argon atmosphere yielded TiN_x solid solutions, which were then comminuted into grains not larger than 60 μm. The oxygen + carbon impurity content in these powders did not exceed 0.3 wt.% and the total metallic impurity content did not exceed 1 wt.%. After the powders had been further comminuted by vibration treatment in benzene for 10-60 h, they were hydrostatically compressed under pressures of 1-5 GPa at normal temperature. For comparison, ultrafine-disperse powders with a specific surface of 11-54 m^2/g produced by plasmochemical synthesis at the LaSSR Academy of Sciences were similarly compressed under a pressure of 6GPa for 30 h only. The fine structure of all powders was examined in a DRON-3 X-ray diffractometer with a CuK_α-radiation source and a graphite monochromator, the latter followed by a scintillation counter. An analysis of these data indicates an vibratory comminution causes the region of coherent scattering to shrink and the microstrains to build up according to a pattern similar to that observed during comminution of TiC_x powders. The pressure dependence of the fine structure was found to follow the same trend, with the region of coherent scattering and the magnitude of microstrains symbatically changing as the total external force action is intensified. In the case of plasmochemically synthesized TiN_x powders was recorded broader X-ray diffraction lines, their width being attributable solely to the fine dispersion and consistent with the grain dimensions measured by the Brunauer-Emmet-Teller method. Figures 1; tables 2; references 14.

539.213

Effect of Alloying on the Surface Composition and Oxidation Resistance of Rapidly Quenched Alloys Based on the $Co_{80}B_{20}$ System

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[Article by V. V. Nemoshkalenko, A. P. Shpak, S. I. Latypov, N. S. Kobzenko, and A. G. Dmitriyev, Metal Physics Institute, Kiev]

[Abstract] Oxidation of $Co_{80}B_{20}$, $Co_{70}Fe_{10}B_{20}$, and $Co_{70}Ni_{10}B_{20}$ amorphous alloys in air at 250°C was studied gravimetrically and by X-ray photoelectron spectrometry. Argon-ion etching was employed to reveal subsurface layers for elemental analysis. Gravimetric curves show that the oxidation resistance of the Co-Fe-B alloy is the lowest and that of the Co-B alloy the highest. Correlation of the gravimetric curves with the X-ray photoelectron spectra and the distribution of the elements over the depth of the surface layer after two and one-half hours of oxidation (the time of formation of oxide film) shows that selective oxidation of boron, which results in a passive B_2O_3 film, provides corrosion resistance, whereas selective oxidation of an element such as iron, which does not passivate the surface, leads to reduced corrosion resistance. Figures 3; 2 Western references.

Combined Use of Laser Processing and Surface Plastic Deformation After Electric-Spark Alloying of Steel With Chromium

907D0125A Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 1, Jan 90 pp 7-9

[Article by G. A. Beresnev, V. P. Bratilov, V. V. Pepelyayev, S. V. Pertsev, and K. V. Shestakov, Perm Polytechnical Institute]

[Abstract] A study is presented of the results of joint application of laser processing and surface plastic deformation to improve the quality of a chromium layer about 0.1 mm thick obtained by electric-spark alloying of the surface of type 38 KhNZMFA steel. Specimens of heat-treated steel were studied on which a layer of chromium had been applied as a system of spots by the use of an automatic vibrator operating at 10 Hz, 20 seconds per spot. Some of the specimens were laser treated with a beam energy of 2-12 J, spot size 1 x 2, 8 x 12 and 17 x 2 mm, overlap factor about 0.5, pulse repitition frequency 1 Hz. Others of the specimens were subjected to surface plastic deformation by diamond smoothing on a screw-cutting lathe by a tool with a radius of 1.5 mm, load 250 N, feed 0.04 mm/rev. Surface plastic deformation was also performed on the specimens which were laser treated. The studies demonstrated the possibility of significantly improving the quality of the electric-spot layer by laser treatment followed by surface plastic deformation. The level of smoothness achieved, with virtually no cracks or tensile residual stresses suggests the process for finishing of products. Figures 6; References 3 (Russian).

Some Specifics of Vacuum Electric-Arc Application of Coatings of Ti-Si Alloy in Nitrogen

907D0125C Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 1, Jan 90 pp 13-14

[Article by Zh. A. Mrochek, B. A. Eyzner, I. A. Ivanov, A. A. Tomchenko, V. I. Ivashneva, Ye. V. Mochaylo, and V. M. Konkov, Order of Labor Red Banner Physical-Technical Institute, Belorussian Academy of Sciences]

[Abstract] Some results are presented from studies of the process of application of coatings obtained by electric-arc evaporation of multicomponent cathodes in a medium of nitrogen, and the technological capabilities of the process of vacuum electric-arc application of coatings are demonstrated for a cathode consisting of a Ti-Si alloy. The coatings were applied on an industrial 0.1 MI installation and qualitative X-ray phase analysis was performed in CuK_{α} radiation with a graphite monochromator. The intensity of the silicide phase lines decreases with increasing nitrogen pressure. Increasing the plasma ion energy leads to synthesis of gamma and beta silicon nitrides starting at a potential of 200 volts. Application of titanium-silicon coatings in a medium of nitrogen is found to result in titanium-silicon and titanium-nitrogen reactions under all conditions tested. The silicon-nitrogen reaction only occurs at a potential of over 200 V. Varying the nitrogen pressure and potential can be used to obtain coatings of titanium silicides without nitrogen, titanium silicides plus titanium nitrides, or titanium silicides plus titanium nitrides and silicon nitrides, significantly expanding the technological capabilities of the method. References 3 (Russian).

Influence of Magnetic Field on Physical and Chemical Properties of Aviation Fuels

907D0125D Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 1, Jan 90 pp 28-29

[Article by I. G. Tretyakov and V. A. Balenko, Kiev Order of Labor Red Banner Institute of Civil Aviation Engineering imeni The Sixtieth Anniversary of the USSR]

[Abstract] Recent studies have indicated an increase in the chemical activity of oxygen upon electromagnetic processing of systems dispersed in water. This article attempts to determine the influence of an electromagnetic field on the kinetics of electrochemical processes in hydrocarbon fuels. The rate of electrochemical corrosion of type St 3 steel in a condensate of type Ts-1 fuel with water and the value of dielectric losses were determined. All studies were performed at 293 K. The studies indicated that the initial values of electrode potentials shifted in the positive direction in the magnetized condensate. An increase was observed in chemical activity of the fuel condensate in electrochemical corrosion processes after magnetic treatment. A sharp increase in the rate of electrochemical corrosion of steel is observed only in the first two to three minutes, afterwards the corrosion process stablizes as the oxide film on the surface of the metal grows and the quantity of dissolved oxygen in the fuel decreases. Figures 2; References 4 (Russian).

Heat Treatment of Iron-Alloy Products By Beam of High-Energy Electrons

907D0125E Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 1, Jan 90 pp 47-49

[Article by G. M. Lonchin, Ye. S. Machurin, and B. P. Molin, Mordovian State Pedagogic Institute imeni M. Ye. Yevsevyev]

[Abstract] A study is made of the heat treatment of steel and cast-iron products by a beam of high-energy electrons. Data are obtained on the liberation of energy and used to study processes of heating of various alloys when they are struck by powerful electron beams. The materials studied included type 40 steel, type 90KhF, R6M5 and U12 steels, gray and bleached cast iron. Electron energies varied from 0.35 to 4 MeV, beam intensities from 1 mA to 1 kA/cm^2, beam diameter from 2 to 10 mm. Heating rates were found to be high enough to achieve a significant temperature difference between the surface and deeper layers of the metals. Melting of

subsurface layers with the surface remaining in the solid state was possible. The resultant hardening of the subsurface layer with good surface quality can significantly improve the wear resistance of steel and alloy products without additional surface layer grinding. A computer program was written to determine beam scanning rates and heat-treatment conditions for the achievement of various goals. Proper selection of conditions can make structure and properties vary with depth. Figures 5; References 4 (Russian).

Influence of Scanning During Laser Surfacing

907D0125F Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV in Russian No 1, Jan 90 pp 82-83

[Article by A. N. Grechin and I. A. Zyabrev, Plant School of Moscow Motor Vehicle Plant imeni I. A. Likhachev]

[Abstract] A study is made of the role of scanning during surfacing and of beam-movement parameters such as frequency and trajectory. Attempts were made to maximize radiation density and use scanning trajectories in which the beam passes repeatedly over a given spot on the surface. This allows the creation of temperature gradients helping to agitate the material in the liquid bath, achieving homogeneity of the coating when multicomponent powder mixtures are used for surfacing. The scanning frequencies used were 50, 150 and 250 Hz, the beam trajectories used were a straight line, ellipse and circle, always with an amplitude of 8 mm. The surfacing rate was varied from 2 to 8 mm/s. Laser radiation power was 2 kW, beam diameter 1 mm, power density $2.7 \cdot 10^5$ W/cm^2. Surfacing was performed on type 45 steel specimens measuring 50 x 25 x 25 mm, the surfacing material being a powder of self-fluxing alloy PG-KhN80SR2 with particle size 40-100 μm, poured directly onto the surfacing zone by a measuring device and transported in argon. Maximum surfacing effectiveness was achieved at v = 2 mm/s. Good quality of surfacing material was achieved at f = 150 Hz at up to 6 mm/s, after which surface layer roughness increased and incomplete melting to the substrate was observed. It was found that the scanning beam allowed the thickness of the layer produced and productivity of the process to be increased. Scanning increased the powder utilization factor from 51 percent to 84 percent while increasing the speed of surfacing by 50 percent. Figures 2; References 3 (Russian).

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